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CLIMATOLOGY AND MINERAL WATERS

OF THE

UNITED STATES

BY

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INTRODUCTION.

It has been my effort in this treatise so to present the ascertained facts in regard to the variety of climate and mineral waters in the United States as to render them available for the promotion of health. To this end, wherever I have not myself observed the conditions described, I have used the observations of others, and, for the most part, in their own words, without regard to any preconceived theory of relative values; that whatever may be the difference in the views of physicians or other persons on the relative value of different climates and mineral waters in particular cases, or for the promotion of health in general, the work will be equally available for all, with regard to the data of any given place or climate, or mineral waters sought.

A. N. BELL.

New York, October 3d, 1885.

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CHAPTER I.

WHAT IS CLIMATOLOGY?

Climatology is the sum of the influences exerted upon the atmosphere by temperature, humidity, pressure, soil, proximity to the sea, lakes, rivers, plains, forests, mountains, light, ozone, electrical conditions, and, doubtless, by some other conditions of which we have no knowledge.

Various efforts have been made from time to time by different writers to classify climates by taking one or more of these elements or forces which constitute climate as an index of its general character. But it is apparent that, in estimating the climate of any place, it is necessary that the force of all the factors should be ascertained severally, in order to arrive at correct conclusions with relation to the general result of the combined action. Moreover, in all such efforts, indeed with reference to climates generally, controllable conditions which exercise influence should be, as far as practicable, considered apart. These are more or less dangerous according to the temperature and hygrometric state of the atmosphere of the place, and have often been so intimately interwoven with natural climatic conditions as to confer bad repute on places which, so far as meteorological influences alone are concerned, are the reverse. Insomuch, indeed, that even so distinguished a sanitarian as the late Edmund A. Parkes was wont to attribute the excessive mortality which used to prevail among the British forces in India and the West Indies to the toleration of unsanitary conditions, rather than to climate. He remarks, in this connection:

"It may seem to be a bold thing to question the commonly received opinion that a tropical climate is injurious to a northern constitution, but there are some striking facts which it is difficult to reconcile with such an opinion. The army experience shows that, both in the West Indies and in India, the mortality of the soldiers has been gradually decreasing until, in some stations in the West Indies (as, for example, Trinidad and Barbadoes), the sickness and mortality among European soldiers are actually less than on home service, in years which have no yellow fever. In India, a century ago, people spoke with horror of the terrible climate of Bombay and Calcutta, and yet Europeans now live in health and comfort in both cities. In Algeria, the French experience is

to the same effect. As the climate and the stations are the same, and the soldiers are of the same race and habits, what has removed the dangers which formerly made the sickness threefold and the mortality tenfold the rates of the sickness and deaths at home?

"The explanation is very simple; the deaths in the West Indies were partly owing to the virulence of yellow fever (which was fostered, though probably not engendered, by bad sanitary conditions), and the general excess of other febrile and dysenteric causes. The simple hygienic precautions which are efficacious in England have been as useful in the West Indies. Proper food, good water, pure air have been supplied, and in proportion as they have been so, the deadly effects attributed to climate have disappeared. The effect of a tropical climate is, so to speak, relative. The temperature and the humidity of the air are highly favorable to decomposition of all kinds; the effluvia from an impure soil, and the putrescent changes going on in it, are greatly aggravated by heat. The effects of the unsanitary evils, which in a cold climate, like Canada, are partly neutralized by the cold, are developed in the West Indies or in tropical India to the greatest degree. In this way, a tropical climate is evidently most powerful, and it renders all sanitary precautions tenfold more necessary than in the temperate zone. But this is not the effect of climate, but of something added to climate.

"Take away these sanitary defects, and avoid malarious soils, or drain them, and let the mode of living be a proper one, and the European soldier does not die faster in the tropics than at home."[1]

These remarks by Dr. Parkes are fully in accord with our own observations and studies, thirty years ago, on the Gulf coast of Mexico and Central America, in the West Indies, and on the west coast of Africa. The sickly places were everywhere marked by unsanitary local conditions.

Recent observations on the climatology and local conditions of foreign ports and places, comprehended in the reports of the Surgeon-General of the United States Navy; the meteorological and other reports of the Surgeon-General of the United States Army; the Smithsonian "Contributions to Knowledge," and the reports of the United States Signal Service Bureau, on all of the more important centres and places in the United States and Territories, and places in intimate commercial relations therewith, abundantly confirm the conclusion of Dr. Parkes and our own observations abroad; and our many years' close attention to the effects of local conditions in conflict with climate throughout the United States.

It is an almost universal practice, which the author of this work follows, to measure the influence of climate by the relation which different regions and localities hold to pulmonary consumption—a disease which

[1] Parkes' "Manual of Practical Hygiene." Wood's Library Edition. Vol. ii., pp. 80–81.

probably more than any other depends upon preventable conditions intimately associated with a foul soil, or density of population.

The Arab, accustomed to the free air of the desert, is said to be afraid of even the outskirts of the town. Many other persons there are, besides Arabs, whose sense of smell is sufficiently acute to detect the odor of great cities at a considerable distance. Yet there are multitudes of people in some of the most salubrious climates in the world, naturally, who fail to appreciate the difference between the stifling air of a badly constructed house and the Arab's tent until they experience the results; or to recognize the fact that no climate is proof against the sickening emanations of a filthy soil, city or country. Primarily, therefore, a sharp distinction should be made between such artificial and local conditions as are removable, and those which are natural and permanent, and measurable by meteorological instruments. It is the latter with which we have most to do in this treatise, excepting only the incidental relations of the former as modifying influences. But unfortunately these incidental relations are so common as to make the exceptions numerous, and it is quite safe to say that there are few, if indeed there are any, cities or villages in the United States, with populations of a thousand and upwards, which are not more or less contaminating to the air of their surroundings by neglected local conditions.

CHAPTER II.

THE ATMOSPHERE—ITS EXTENT AND PHYSICAL PROPERTIES.

The air is the first condition of life, the first element of our bodily tissues. It enters our bodies by the lungs, is absorbed by the blood, and courses through the system. By breathing alone, the air supplies three-quarters of our bodily nourishment, and the other quarter, which is taken in the form of liquid and solid aliment, consists of substances chiefly composed of the same elements.

An intimate acquaintance with the extent, properties, composition, and external relations of the atmosphere is, therefore, an essential pre-requisite to a correct comprehension of the conditions of climate.

The extent of the atmosphere which surrounds the earth is estimated by astronomers to be about forty-five miles from the surface, but with uniformly decreasing density. It is, when pure, colorless, transparent, inodorous, tasteless, and so elastic that it may be condensed to nearly the specific gravity of water, or expanded by heat to thrice its volume—never, however, losing its gaseous condition. It is also ponderable; this was first made evident when Galileo pointed out to the pump makers of Florence the reason why they were not able to raise water in their pumps to a greater height than thirty-two feet—because the weight of a column of the atmosphere was not sufficient to balance it. Toricelli, his pupil, demonstrated that the pressure of the atmosphere which would support a column of water thirty-two feet high, would support a column of mercury only thirty inches high, because mercury is fourteen times heavier than water. This he did, by taking a tube about thirty-three inches long, holding his finger at the bottom, and filling it with mercury; then dipping the lower end into a basin of mercury, and removing his fingers from the bottom of the tube, the mercury was found to remain in the tube to the height of thirty inches from the surface of that held in the basin. This experiment was the first invention of the barometer, and the first actual demonstration of the weight of the atmosphere. Now, inasmuch as a column of mercury one inch square and thirty inches high weighs fifteen pounds, and this, at the level of the sea, is sustained by the superincumbent weight of the atmosphere, therefore a column of atmosphere one-inch square and forty-five miles high is of the same

weight as the column of mercury thirty inches high—fifteen pounds. Hence the barometric pressure of the atmosphere at the sea level is demonstrated to be fifteen pounds to the square inch of surface.

The pressure of this great weight upon our bodies is not felt by us on account of its perfect diffusion around, and through our bodily tissues, and because the force in one direction upon the surface of our bodies is equally resisted in another, though it is so enormous that a man of ordinary size sustains a weight of nearly fifteen tons.

The atmosphere is subject to a law which characterizes all elastic fluids, namely, it presses equally on all sides; and when any portions become lighter than the others, the denser portions rise into their place and force them to seek a rarer medium, always creating a current from the point of greatest to that of least pressure. When the disturbing cause is local, transient, and irregular, partial derangement ensues on account of the action necessary to cause a speedy adjustment. But as the local disturbances are always as much wanting on one side as they are in excess on the other, they are equivalent to undulations of the same medium. Their balance will still maintain an equality of pressure, and whatever may be the disturbing causes, the restoration of the equilibrium is the object of all the motions excited.

In the free atmosphere its own weight is a compensating force, consequently its weight and elasticity both diminish in ascending from the ocean level.

The atmosphere rotates with the earth upon its axis, and consequently in its upper regions, and over the equator especially, it is hurled with incalculable swiftness and to the utmost degree of attenuation. Moreover, penetrated by the sun's rays and in conjunction with the heat of the earth, it is rarefied and acquires endless motion near the earth's surface, which gives rise to winds varying in force from the gentlest breeze to the raging tornado.

The special movements caused by the action of the winds and tempests are limited in their height, and varied in their intensity by the effect of the seasons and the altitude above the level of the sea. But so complete is the agitation by the continual disturbance going on in the lower regions by these forces, that no difference has ever been discovered in the chemical components of the air at the various elevations at which it has ever been possible to collect it for analysis.

The decreasing weight of the atmosphere at increasing height, as measured by the barometer, has afforded the means of calculating its approximate limits.

"By means of this decrease in the density of the air in proportion to its height, Biot has, by an examination of the physical conditions of equilibrium and a complete discussion of the observations obtained at different degrees of altitude by Gay-Lussac, Humbolt and Boussingault, demonstrated that the minimum height of the atmosphere is 16,000 feet or

about thirty miles. At that height, the air must be as rarefied as beneath the exhausted receiver of an air-pump; that is to say, as rarefied as the nearest approach to a vacuum that we can make."[1]

The decreasing density with altitude is so rapid that four-fifths of the weight of the atmosphere is within eight miles of the surface of the earth, leaving one-fifth only for the remaining thirty-seven miles of altitude, and so much rarefied that at the utmost limit one cubic inch is estimated to have expanded to 12,000 cubic inches.

The decreasing density is well illustrated by the boiling-point of water, which at the level of the sea is 212° F. By decreasing the pressure on the surface of the water, which is readily done by placing it under an air-pump, the boiling-point is lessened in proportion as the superincumbent weight of the air is removed; as the weight of the atmosphere may also be overcome, and the pressure proportionally lessened by ascending a mountain. Professor Tyndall states that the boiling-point of water on Mont Blanc (at the altitude of 16,000 feet) is 184.95° F., or 27° below that of the sea-level—a decrease of one degree for every 596 feet of ascent. On the other hand, if the pressure be increased, the boiling-point will be raised. It has been found that by doubling the atmospheric pressure, making it 30 pounds to the square inch of surface, the boiling-point of water is raised to 294.5° F.

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[1] "The Atmosphere." Translated from the French of Camille Flammarion. Harper & Bros. P. 31.

CHAPTER III.

THE COMPOSITION OF THE ATMOSPHERE.—ITS PERMANENT CONSTITUENTS.

OXYGEN AND ITS PROPERTIES—OZONE?—PRODUCTION, DISTRIBUTION, AND PROPERTIES—TESTS AND USES; NITROGEN.

THE composition of the atmosphere mainly consists of two permanent gases—oxygen and nitrogen, in the proportion of

Oxygen	23 parts in weight ;	20.8 in volume
Nitrogen	77 " " "	79.2 " "

OXYGEN is the-life-sustaining element of the atmosphere. In its separate state it is a little heavier than common air: specific gravity, compared with air as unity, 1.1056. It is colorless, transparent, and without odor; soluble in water in the proportion of about five per cent by volume, and by pressure to a much greater extent. Submitted to animals, they breathe it at first with evident delight. It greatly excites them, but quickens the vital processes to such a degree as to throw them into a state of fever, and finally kills them by excess of excitement.

On the other hand, if an animal be placed into the residue of the air—that from which the oxygen has been abstracted—it suffocates instantly, without the power to take a single breath.

If a lighted candle be placed in pure oxygen, it burns with greatly increased brilliancy and rapidity, and so of all other combustible substances; but where there is no oxygen they will not burn at all.

Such experiments show that oxygen is absolutely necessary to sustain life, and to support combustion; and that without the presence of oxygen there can be no life or heat.

Oxygen possesses the property of readily combining with other substances, by a process called *oxidation*, which is analogous to combustion. It is in virtue of this property that wherever oxygen has free access to dead organic matter, the destruction of such matter is greatly promoted, and putrefaction prevented.

To this specially active *property* of oxygen, under certain circumstances and influences, or rather *to* oxygen in an exalted state of activity, is given the name of *ozone*.

OZONE seems to have been recognized by the ancients, though without any knowledge of its nature. Jupiter is said to have struck a ship

with a thunderbolt "quite full of sulphurous odor" (*Odyssey*, B. XII., v. 417, and XIV., v. 307); to have "hurled a bolt, with the flame of the burning sulphur," into the ground before Diomedes' chariot (*Iliad*, VIII., 135); and "Ajax hurls a rock at Hector, who falls like a mountain oak struck by lightning, which lies uprooted, and from which the fearful smell of smoking sulphur arises" (*Iliad*, XIV., 415).

Ozone was first particularly described about a century ago by Van Mavurn, but its nature was not discovered until in 1839 by Schönbein, of Basle, the inventor of gun-cotton, while engaged in some experiments on the decomposition of water by voltaic electricity. He showed that the odor was produced by the oxygen evolved at the positive pole during the decomposition of water by the voltaic pile. His subsequent experiments, confirmed by other chemists, have established the conclusion that Ozone is an "electricized" or "*active* oxygen."

Dr. Cornelius Fox, in his work on Ozone and Antozone, sums up the researches on the nature and properties of Ozone as follows:

"Ozone is simply a condensed or allotropic form of Oxygen, and that they (Oxygen and Ozone) are mutually convertible, the one into the other, without the production of any other body. Ozone may be prepared:

1. By passing through oxygen or air a number of electric sparks. Many apparatuses have been constructed for producing ozone in this manner.

2. By the electrolysis of acidulated water. Baumert obtained by the electrolysis of water acidulated with Sulphuric Acid .0154 grain of ozone in 150 litres (9,150 cubic inches) of odorous oxygen; and the same amount in 10 litres (610 cubic inches) when Chromic Acid was substituted for the Sulphuric Acid.

3. By placing a stick of Phosphorus scraped clean in the bottom of a vessel of air containing sufficient tepid water to half submerge it. After the lapse of an hour or two, the production of Ozone attains its maximum. The Phosphorus should then be withdrawn, and the inclosed air well washed, to remove the Phosphoric Acid. If the Phosphorus be allowed to remain, the Ozone by degrees disappears, owing to the combination of the metalloid.

4. Ozone is formed by the action of strong Sulphuric Acid upon Potassium Permanganate. Böttger[1] mixes very gradually three parts of the acid with two parts of the salt. The mixture, he states, will continue to give off Ozone for several months. This mode of preparing Ozone is preferred by me for the purification of the air of hospitals, halls for public assemblies, etc.

5. By dispersing water in a pulverized form through the air.

6. By the introduction of a hot glass rod into a vessel of air through which the vapor of ether has been diffused. The preparation of ozone

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[1] Zeitschrift für Chem. und Pharm., Bd. iii., S. 718.

in this manner is somewhat troublesome, on account of the difficulty experienced in obtaining the proper temperature. If the rod is not sufficiently heated, no ozone will be generated, and if it is too hot, any that may have been formed will be immediately converted into common oxygen. The formation of ozone in this case, as in that where it is produced by clean moist phosphorus, appears to be simultaneous with the partial oxidation of the acting substance.

7. By the slow oxidation from exposure to light and air of certain ethers, volatile and resin oils, and other bodies which have been denominated "ozone-carriers," such as sulphuric ether, chloroform, oil of turpentine, lemons, linseed, cinnamon, bergamot, and most essential oils, the blood-corpuscles, etc. These bodies are said to absorb ozone without combining with it, and to possess the property of yielding it up to other substances. They bleach solutions of indigo and other plant-colors, and give a blue color with guaiacum and iodized starch papers. Some have said that these essential oils which have undergone exposure do not betray the presence of ozone, but of the peroxide of hydrogen. The "turps" sold in the shops sometimes contains as much as 50 per cent of its volume of one of these oxidizing principles.

Dr. Day, of Geelong,[1] has advocated the employment of one of these "ozone carriers" for sanitary purposes. He recommends that the shirts, blankets, bed-clothing and bandages of the sick be sprinkled with an ether which has undergone this process of oxidation.

The various kinds of ethers differ much with respect to the amount of ozone contained in them, as the following table will show:

TABLE.

Ethers, etc.	Reaction with red and blue Litmus.	Ozone Tests.	
		Iodide of Potassium.	Iodized Starch.
1. Ether at least ten years old	Acid	No. 9	No. 5
2. Commercial methylated ether	Slightly acid	3	1¾
3. Methylated absolute ether	Neutral	4	3
4. Refined methylated ether	Very slightly acid	3	2
5. Absolute ether (æther purus), P. B.	Very acid	10	5
6. Dr. Richardson's ozonic ether	Very strongly acid	11	10
7. Another spec. of absolute ether	Very slightly acid	4	2½
8. A third spec. of absolute ether (recently made)	Faintest trace of acidity	2½	2
9. Rectified spirit	Neutral	½	1½
10. Chloroform	Neutral	0	0

It will be observed that the three ethers most highly ozoniferous are more acid than the others. Suspecting lest the ethers yielding decidedly

[1] Lancet, February, 1866.

acid reactions might contain some acid peroxide of hydrogen, which decomposes iodide of potassium like ozone, I tested each of them with a sulphate of manganese paper (which had been colored by ozone), and with solutions of the permanganate of potash and chromic acid, with the following results:

Ethers	(a.) Colored Sulphate of Manganese Test.	(b.) Solution of Permanganate of Potash.	(c.) Solution of Chromic Acid.
1. Old ether..	Color slightly increased..	Color changed to brown.	Unchanged.
5. Absolute ether.	do.	do.	do.
6. Dr. Richardson's ozonic ether.	Removed of all color.....	Complete bleaching.....	Blue color produced.

Pure peroxide of hydrogen is characterized by the property of bleaching the peroxide of manganese and permanganate of potash tests, and of forming a blue color with chromic acid. The numbers 1 and 5 ethers, like ozone, behave in a manner quite different when submitted to *a* and *b* tests, and are quite unable to exhibit the beautiful blue tint with chromic acid.

It is evident, then, that the action of Dr. Richardson's ozonic ether on the iodide of potassium tests is due to the peroxide of hydrogen which has doubtless been mixed with it. As ozone is superior as an oxidizing agent to oxygenated water, the old ozoniferous ethers are to be preferred. Exposure to air and light seems alone necessary for the ozonization of ethers. This change may be easily effected by exposing to the light a small quantity of ether at the bottom of a very large, well corked bottle.

As deodorizers and disinfectants, ozoniferous ethers are very useful to physicians and nurses in their attendance on the sick. They should be sprinkled over handkerchiefs, garments, and the bed linen of fever cases. Their employment in the wards of hospitals is highly desirable. As those which should be alone employed for sanitary purposes are extremely powerful, it is only necessary to use a very small quantity at a time. A drop or two of either of the ethers numbered 1 and 5 allowed to moisten a handkerchief, in which an iodide of potassium test has been wrapped, very rapidly colors it.

8. Ozone is said to be produced by the addition of concentrated sulphuric acid to the binoxide of barium, also during the combustion of hydrogen, carbide of hydrogen, and of kindred gases, and in the processes of fermentation and putrefaction. Whenever, in fact, a chemical reaction takes place in the presence of atmospheric air, oxygen is said to be ozonized. . . .

THE PROPERTIES OF OZONE.—"Ozone is insoluble in solutions of the acids and alkalies, in alcohol, ether, essential oils, and in water. It quickly purifies the last-named fluid if charged with any organic matters. . . .

It acts on most substances as an *oxidizing* agent of great power, converting indigo and isatin, the black sulphide of lead into the white sulphate of lead, and the yellow ferrocyanide into the red ferricyanide of potassium. The metals, arsenic, antimony, iron, manganese, zinc, tin, lead, bismuth, silver, and mercury, are oxidized by ozone. It also transforms many of the lower oxides into peroxides. Schönbein states that nitrites can be changed into nitrates by ozone only, whilst antozone and neutral oxygen have no action on these salts.

It deoxidizes or reduces a small class of bodies, such as the peroxides of hydrogen and barium which become water and baryta respectively, being at the same time itself converted into oxygen. When brought into contact, under certain circumstances with ammonia, it forms, according to Dr. Wood, a specific compound or salt—an ozonide of ammonium.

Its corrosive powers, and its property of destroying most organic substances are remarkable. In its concentrated state it possesses bleaching properties superior to chlorine. The experiments of Baumert, Schönbein, and Gorup-Besanez show that wood, straw, cork, starch, vegetable colors, caoutchouc pure and vulcanized, the fats and fatty acids, alcohol and albumen, are oxidized by this agent.

Ozone is thought by some to be absorbed by the blood-corpuscles with great rapidity, oxygen being liberated. Küne, on the contrary, is of opinion that the blood-globules ozonize the oxygen with which they come into contact, without themselves undergoing any change.

Ozone possesses the power of destroying by oxidation the putrid exhalations, such as sulphuretted hydrogen, etc., from decomposing organic matters. In illustration of its deodorizing and purifying effects, the following experiment was performed by Drs. Wood and Richardson. In 1854, a pint of the blood of an ox coagulated was exposed to the air until it was quite putrid, and the clot was softening. At the close of the year, the clot having redissolved as a result of alkaline decomposition, the blood was a most offensive fluid. In 1862, the fluid was found to be so offensive as to produce nausea when the gases evolved from it were inhaled. Drs. Wood and Richardson subjected it to a current of ozone from Siemens' apparatus. Gradually the offensive smell passed away, and the fluid mass became quite sweet. The dead blood, moreover, coagulated as the products of decomposition were removed, and this so perfectly, that the new clot exuded serum."[1]

The *tests* for ozone are:

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[1] Ozone and Antozone. Their History and Nature. By Cornelius B. Fox, M.D. Edin., Member of the Royal College of Physicians, etc. London: J. & A. Churchill, pp. 29, 30.

1. (Schönbein's) Take of pure iodide of potassium	1 part.
Starch	10 parts.
Distilled water	200 "

Boil together gently for a few minutes; and saturate slips of white, unsized bibulous paper in the liquid. Dry them away from light and air. When used they must be sheltered and shaded from sunlight and rain. Acted upon by ozone, the paper will be changed from white to violet. To bring out the color fully, dip the test paper into water at the end of the experiment, and compare the shade with the color scale prepared for the purpose.

2. (Fremy's). Soak white bibulous paper in an alcoholic solution of guaiacum, and dry in the dark. Exposed to an ozonized atmosphere, the paper will acquire a blue color.

3. Moisten a strip of white bibulous paper in a solution of pyrogallic acid; when exposed to an ozonized atmosphere, it is rapidly darkened. Negative test. Ozone is present in the air when Condy's fluid, diluted with distilled water and exposed to it, does not change color.

A paper on the "Atmospheric Ozone, and the Best Methods for its Observation," by A. W. Nicholson, M.D., published in the Michigan State Board of Health Report for 1880, contains the following practical observations:

"The principal experiments conducted by myself have been to determine the presence of ozone in dwellings, and the probable influences affecting such test; to determine the relative amount of ozone in pine forests, compared with observations taken in the open country; to ascertain the relative amount of the same element by experiments conducted in the smoky atmosphere in proximity to a large number of "pits" for the manufacture of charcoal; to estimate the amount of ozone existing over swamps; and to compare the amount of the same by the exposure of tests at the differing elevations of four feet and fourteen feet from the ground. Experiments were also made with regard to the influence of decomposing animal excreta upon the test, compared with tests made one hundred feet distant from the first, or from any such element of contamination. Observations also were made to determine the effect of excess of humidity upon the test; and, lastly, to determine the difference in the quantity of active oxygen present in the atmosphere of a malarious region with that of an atmosphere in a non-malarious region, the same test being employed in both localities, and the observations being taken at the same hours of the day.

"Many of these observations may be but repetitions of those made by other observers, but the information already obtained is only sufficient to act as an incentive to other investigators to continue their labors in this direction. If there is no veritable connection between the varying proportions of ozone or active oxygen and health or disease, inquiry should be continued until the proof of this fact is substantiated. If

there is a relation, though slight, the solution of the problem is worthy of the most untiring study.

"In experimenting to determine the proportion in the atmosphere of oxidizing elements bearing a relation to health and disease, it does not seem necessary to employ a test that will verify only the existence of a single factor like that of ozone. Oxygen in a state of activity, whether generated by electrical or other influences, from oxygen in a nascent condition, or from products that easily liberate oxygen in a state of activity, like the essential oils, peroxide of hydrogen, or resinous compounds, is the desired factor to be searched after by the sanitarian and etiologist. If the test detects compounds that in themselves produce a coloration of the test paper, it appears equivalent to a determination of an equal amount of active oxygen.

"Is ozone to be discovered as existing in dwellings?

"Max von Pettenkofer, of Munich, in an article in the *Contemporary Review*, entitled, 'The Hygienic Influence of Plants,' makes the following assertion in regard to the relation of ozone to the appearance or disappearance of disease: 'But one fact which was observed from the first shows that it cannot be so; for the presence of ozone can never be detected in our dwellings, not even in the cleanest and best ventilated. Now, as it is a fact that we spend the greater part of our lives in our houses, and are better than if we lived in the open air, the hygienic value of ozone does not seem so very great.'

"Such a declaration, proceding from such an influential origin, would, if erroneous, lead to many false deductions. That it is incorrect, the succeeding exhibit of the results of observations taken by himself, appears to prove. The observations were made with Schönbein's test, moistened before exposure. The apartment where the experiments were made was well constructed, and a free circulation from the external air permitted, when there was the greatest coloration, allowing motion to the air and access of moisture. Where least coloration occurred every avenue to the external air was closed as much as possible.

EXHIBIT A.

Date.	Internal Observation.		External Observations.		Remarks.
1880.	Night.	Day.	Night.	Day.	
June 10..	....	1	....	3.5	All numbers correspond to scale of 10 degrees of coloration.
" 11..	0	1	2	3	
" 12..	1	2	2.5	3	
" 13..	2	2.5	3.5	3	
" 14..	1	1	3.5	3	Strong wind.
Average ..	1	1.5	2.9	3.1	

"During the winter, in a north room of my own dwelling, where an effort was made to exclude the factor of ventilation, a coloration of three degrees was obtained. The temperature of the room was fifteen degrees Fahr., and a strong wind was blowing from the north. Externally a coloration of nine degrees was obtained. At the same time, in another north room of the same house, where the temperature amounted to seventy degrees Fahr., a distinct trace was discernible. At another time, when the external air was quiet, there was obtained one degree of coloration in the first room, where the temperature was forty-five degrees Fahr., and in the second room no coloration, with a temperature of seventy degrees Fahr. These results would suggest that a certain amount of motion of the air exceeding that usually existing in dwellings would be auxiliary to conditions producing a manifestation of the presence of ozone therein. That the excess of moisture *externally* over that in the *interior* of dwellings is not a factor to be considered, seems proved by experiments made by the writer in regard to effects of moisture on the test as existing in dwellings. It was found that in rooms ventilated, when the external air was not disturbed by the influence of storms, the amount of moisture (absolute humidity) internally was equal to the amount of moisture externally, and that there was sometimes an excess of moisture in the interior of a dwelling over that the exterior, when the amount of ozone was slight or entirely absent in dwelling.

"It is probable that sunshine is a condition aiding the production of ozone in dwellings, as more ozone was present during the day than night.

"Prof. R. C. Kedzie says: 'Ozone is doubtless formed in every sunlit room, and by its formation and destruction a vast amount of *materies morbi* may be destroyed, and it is no satisfactory proof that it is of no worth or influence because no residual ozone remains to act upon our test-paper.'

"Just what influence upon the test is that is produced bythe presence of carbon compounds, it is difficult to express. That its presence may modify the results of an experiment to ascertain the amount of ozone present is possible. To determine if the presence of pure carbonic acid would decolorize a slip of test-paper, already colored by exposure, I subjected a moistened slip to an atmosphere of carbonic acid by collecting the same over a pneumatic trough. On the gas being washed by passage through water, the color upon the slip remained unaltered. On subjecting it to the influence of the gas as it escaped unwashed from the generator, a decolorization immediately occurred. This was found to be due to the presence of sulphurous acid.

"Smoke is an element that will decolorize a slip of the test-paper already charged with liberated iodine. It is probable that the volume of smoke that usually, though imperceptibly, escapes from the stove, contains some property, perhaps that of sulphurous acid, that causes a change

in the iodine as rapidly as it is liberated, resulting in the formation of a colorless iodate. To demonstrate the effect of gases, or smoke, generated by the stove, I introduced a glass tube through an opening of the stove into the midst of burning coals, and into the outer extremity of the tube I placed some of the test-paper already colored by the action of ozone. The result was a marked loss of the color on the paper. That this was not due to the action of increased temperature was proved by exposing a similar paper to the action of the same temperature at other points.

"Although it is apparent that the amount of ozone in dwellings is actually less than that in the external air, it is also true that there exist agents that at present prevent an accurate estimate from being obtained by Schönbein's test. That active oxygen bears to organic life—to physiological and pathological conditions—some essential relation, is a proposition yet open for discussion. To declare that its presence in dwellings is not proved is apparently an error. Even were it absent from dwellings, that circumstance could not prove its non-relation to health or disease. Without endeavoring to court discussion upon this important subject, it seems plausible to the writer that no oxygen enters the blood in ony other state than as active oxygen. It may be that the large area of the alkaline pulmonary secreting surface, subject to the results of continuous evaporation, is in a condition to effect a generation of sufficient active oxygen to supply the blood with that which it requires. The excess in the external atmosphere may be of importance to the individual when a decrease in the external temperature intuitively directs him to take less deep inspirations than the warmer and drier atmosphere of the dwelling demanded, thus rendering the labor of the lungs less in supplying a given quantity of oxygen to the blood. If it should be objected that the ratio of active oxygen necessary to sustain the physiological requirements of the blood is not constant, I would inquire if the ratios of most meteorological conditions are constant.

"During portions of the months of March and April, 1878, while the ground was frozen, and part of the time overspread with snow, I secured a record of observations of the amount of ozone in a small pine forest, about eight miles distant from my usual point of observation. The following exhibit represents the comparative amount existing at both places at the same time.

"It is generally believed that ozone, or that product nearly identical in its nature, the peroxide of hydrogen, exists in excess amidst coniferous vegetation over that found in most other regions, but the above exhibit presents results contrary to that which ought to be expected to exist. This difference is, no doubt, in a great degree due to the time of year being when there was the least development of vegetable products, to the more confined circulation of the air, and perhaps to excess of humidity. The ground was low.

EXHIBIT B.

Date. 1878.	Pine Forest.		Open Country.		Date. 1878.	Pine Forest.		Open Country.	
	Night.	Day.	Night.	Day.		Night.	Day.	Night.	Day.
March 4....	6	5	8	4	March 20....	4	5	5	3
" 5....	6	5	6	4	" 21....	5	4	4	4
" 6....	6	5	4	5	" 22....	5	4	8	5
" 7....	6	5	10	8	" 23....	5	5	5	5
" 8....	4	4	8	7	" 24....	4	6	4	6
" 9....	5	4	5	4	" 25....	5	5	5	5
" 10....	5	5	8	4	" 26....	5	5	5	5
" 11....	5	5	6	8	" 27....	4	4	8	5
" 12....	5	5	10	9	" 28...	4	4	9	8
" 13....	6	5	10	9	" 29....	4	5	8	4
" 14....	4	5	8	9	" 30....	5	5	4	4
" 15[1]....	2	4	1	4	" 31....	5	5	9	8
" 16....	5	5	10	8	April 1....	5	5	......	7
" 17....	5	5	9	10	" 2....	5	4	5	3
" 18....	4	5	9	8	" 3....	4	3	4	3
" 19....	6	5	8	7					
					Average......	4.80	4.70	6.93	5.90

"During the preceding summer, in the months of August and September, I secured the results of observations taken in the same pine forest, as represented in the following exhibit:

EXHIBIT C.

Date. 1877	Pine Forest.		Open Country.		Date 1877.	Pine Forest.		Open Country.	
	Night.	Day.	Night.	Day.		Night.	Day.	Night.	Day.
Aug. 26.....	3	4	1	4	Sept. 11.....	0	1	1	2
" 27.....	4	3	3	4	" 12.....	2	3	3	3
" 28.....	0	1	0	1	" 13.. ..	0	3	0	2
" 29.....	3	4	2	3	" 14.....	0	4	0	3
" 30.....	1	3	1	2	" 15.....	3	3	2	3
" 31.....	4	2	3	4	" 16.....	2	3	2	3
Sept. 1.....	4	4	4	3	" 17.....	4	4	3	4
" 2.....	1	4	..	3	" 18.....	3	4	1	4
" 3.....	3	3	3	4	" 19.....	3	4	2	4
" 4. ...	3	4	3	4	" 20.....	1	3	1	2
" 5.....	2	3	2	3	" 21.....	1	4	1	3
" 6.....	3	3	3	4	" 22.....	2	3	0	3
" 7.....	1	4	1	4	" 23.....	3	4	1	3
" 8.....	1	3	1	3	" 24.....	3	2	3	3
" 9.. ..	1	4	1	4	" 25. ...	1	2	2	3
" 10.....	3	1	3	3					
					Average.....	2.09	3.13	1.80	2.16

[1] Frost on night ozonoscope.

NOTE.—Night observations, from 9 P.M. to 7 A.M.; day observations, from 7 A.M. to 2 P.M.

"In the above exhibit we find a considerable difference in the two averages of night ozone, that found in the pine forest being in excess. The variation in the amount of ozone ascertainable during the day was slight. Were a sanitarium to be established in the vicinity of a pine forest for the sake of the salubrity of its immediate atmosphere, it would appear expedient to consider other elements liable to affect the health than ozone alone.

EXHIBIT D.

Date. 1877.	Coal Pits.		Open Country.		Date. 1877.	Coal Pits.		Open Country.	
	Night.	Day.	Night.	Day.		Night.	Day.	Night.	Day.
Aug. 1......	2	3	2	4	Aug. 12.....	2	3	3	4
" 2......	1	2	1	2	" 13.....	2	3	3	4
" 3......	1	3	1	4	" 14....	1	3	3	4
" 4......	1	2	0	3	" 15.....	1	3	2	4
" 5......	1	3	1	4	" 16.....	1	5	1	2
" 6......	2	4	4	4	" 17.....	2	3	1	3
" 7......	1	3	2	3	" 18.....	1	3	0	4
" 8......	1	4	3	3	" 19.....	1	2	1	4
" 9.....	1	4	2	4	" 20. ...	2	2	1	4
" 10......	2	3	3	4	" 21.....	1	2	2	4
" 11......	1	4	0	3	Average.....	1.33	3.00	2.71	3.57

"Exhibit D records the results of observations taken in the borders of a pine forest, but in close proximity to coal-pits, as compared with those taken at a distance and free from any known cause of local disturbance to the test. The heavy night air at the pits was surcharged with smoke that during the daytime was less concentrated. The results of the observations at this point were, at night, almost negative, although recorded as one degree of coloration whenever a trace was discernible. The negative results obtained here are accounted for by the presence of the discolorizing carbonaceous elements of the atmosphere associated with the element of excess of humidity. It does not seem unreasonable to conclude that the quantity of ozone present in an atmosphere subjected to the above-mentioned influences cannot be determined by the employment of Schönbein's test.

"During the construction of these coal-pits, in the year preceding these experiments, the amount of sickness at, and near to, them was very great. In a population amounting to one hundred and fifty, nearly one-fourth were simultaneously afflicted with fevers of a periodic type. Clay and porous soils were being overturned for the first time, and large belts of timber were being felled, opening avenues for swamps and ponds. The greatest prevalence of sickness was during the burning of some of the pits first constructed. The season during which the obser-

vations were taken was marked by a diminution in the number of cases of fever.

"Another month's observations, taken at the same place, gave results almost identical to those above given.

"The following exhibit represents the comparative amount of ozone existing over a swamp two miles from the point where the observations were taken with which they are compared. They were also taken simultaneously with those observations relating to the quantity of ozone existing in a pine forest.

EXHIBIT E.

DATE. 1877.	OVER SWAMP.		POINT FREE FROM SUCH INFLUENCES.		DATE. 1877.	OVER SWAMP.		POINT FREE FROM SUCH INFLUENCES.	
	Night.	Day.	Night.	Day.		Night.	Day.	Night.	Day.
Aug. 26	1	2	1	4	Sept. 10	0	0	3	3
" 27	1	2	3	4	" 11	0	1	1	2
" 28	1	1	0	1	" 12	0	3	3	3
" 29	1	3	2	3	" 13	0	1	0	2
" 30	1	1	1	2	" 14	0	2	0	3
" 31	4	5	3	4	" 15	2	2	2	3
Sept. 1	0	1	4	3	" 16	1	2	2	3
" 2	0	0	3	3	" 17	0	3	3	4
" 3	0	1	3	4	" 18	0	1	1	4
" 4	0	3	3	4	" 19	....	...	2	4
" 5	0	1	2	3	" 20	0	5	1	2
" 6	0	1	3	4	" 21	0	4	1	3
" 7	0	1	1	4	" 22	0	0	0	3
" 8	0	3	1	3					
" 9	0	5	1	4	Av'ge,	0.44	1.92	1.78	3.17

"In the above exhibit a great difference is seen to exist between the averages of the two points of observation.

"Whether this difference is due to the emission of gases destructive to a large portion of the atmospheric ozone naturally present, or whether the same interferes with a deposition of liberated iodine, or whether the apparent absence is due to an excess of moisture sufficient to decolorize the paper, are inquiries that can only be determined by experimentation. The excess of humidity naturally present at such a point appears to offer some explanation.

"The experiments over the swamps were made by suspended slips of test-paper about three feet above the soil. They were exposed to a free circulation of the air, but protected from the sunlight. During the time these observations were being taken the several families residing near the swamp suffered more or less from frequent attacks of periodic fever.

"With a view to ascertain the comparative results of observations for the presence of ozone as it existed at two different points of elevation,

fifty-four observations were conducted at the elevations of four and fourteen feet from the ground.

"The following exhibit contains the result of these observations:

EXHIBIT F.

	Higher Elevation.		Lower Elevation.		Remarks.
	Night.	Day.	Night.	Day.	
	4	9	7	9	Rain all day.
	8	8	9	7	Rain all day.
	7	7	8	8	Rain all day.
	9	5	8	5	Rain in night.
	4	4	8	6	Rain in morning.
	7	5	8	5	Rain all day.
	4	5	5	6	Fair.
	5	5	6	5	Fair.
	4	3.5	4	3.5	Fair.
	4	3.5	3	3.5	Rain in night, paper lost color.
	1	4	2	4	Fair.
	2	3	2	3	Fair.
	3.5	..	3.5	..	Fair.
	1	4	3.5	4	Fair.
Average..	4.53	5.07	5.50	5.30	

"These observations do not demonstrate that actually a greater quantity of ozone was present in the lower stratum of the air than in the upper. The variation of the degree of moisture at the two points may lead to an explanation; yet the excess of ozone at the lower plane seemed to correspond with the presence of aqueous precipitation and a consequent pulverization of the rain-drops. This might have led to the generation of ozone by increase of electrical influences, as spoken of by Fox in his work on 'ozone.'

"At the suggestion of Dr. Baker, I directed my attention to the relative quantity of ozone existing near decomposing animal excreta as compared with that found one hundred feet distant from any such contaminating influence.

EXHIBIT G.

Date, 1879.	Impure Air.		Pure Air.	
	Night.	Day.	Night.	Day.
June 9	2.5	3.5	4.5	3.5
" 10	2	2.5	3.5	3.5
" 11	1	3	2	3
" 12	2	2.5	2.5	3
" 13	3	....	3.5	....
" 14	3	3	3.5	3
Average	2.3	2.9	3.3	3.2

"Both ozonoscopes were suspended at a distance of six feet from the ground, and both were subjected to the influence of the same degree of atmospheric humidity. It is therefore probable that the variation in the degree of coloration was due to the exposure of one ozonoscope to the influence of rapidly oxidizing effete material.

"In considering the influences existing that might have occasioned an error in the results of the observations recorded in the foregoing exhibits, none is more apparent than that of excess of moisture. Some atmospheric conditions associated with twenty observations where there was a total absence of coloration are shown in the succeeding exhibit:

EXHIBIT H.

No. of Case.	Lowest Temperature.	Velocity of Wind—Miles per Hour.	Relative Humidity.	Remarks.
1.........	44	2	75	Few clouds.
2.........	37	2	96.6	Cloudy. Frost on test-paper.
3.........	34	2	96.6	Frost.
4.........	32	2	96.6	Slightly cloudy.
5.........	32	2	96.6	Slighty cloudy.
6	32	2	96.6	Slightly cloudy.
7.........	32	2	96.6	Slightly cloudy.
8.........	25	2	100	Slightly cloudy.
9.........	41	2	96.6	Slightly cloudy.
10....... .	45	12	100	75 per cent of clouds. Heavy dew.
11.........	44	2	100	Heavy dew.
12.........	57	2	100	Smoky—75 per cent of clouds.
13.........	44	2	85	Heavy dew.
14.........	44	2	100	Heavy dew. No clouds.
15.........	44	2	100	Heavy dew.
16...... . .	59	2	100	Heavy fog—50 per cent clouds.
17.........	46	2	96.6	Heavy fog—75 per cent clouds.
18.........	49	2	96.6	Heavy dew. No clouds.
19...	25	2	100	Frost. No clouds.
20..	57	2	96.6	90 per cent clouds.

"The above cases represent nearly all those of complete obliteration of color occurring during a period of three years. *These all occurred during the night observation.* With each case there was nearly, or quite, a complete saturation of the atmosphere with moisture.

"In one hundred and forty-three observations taken by myself to determine the relative value of Schönbein's test when exposed to the air dry, and when exposed after having been previously moistened, I discovered an excess of coloration in the dry slip over that of the wet slip forty times, the largest excess being five degrees of coloration. During these forty instances the sky was covered with one hundred per cent of clouds. In only six instances in the whole number of observations was the wet slip colored in excess of the dry when there was one-hundred per cent of clouds. When there was less than seventy-five per cent of clouds

the *moistened* slip was more greatly colored than the dry. While I at one time thought it possible that some electrical phenomena might be a cause of the ozonoscopic conditions just mentioned, I am now disposed to believe the cause to bear relation more to hygrometric states influenced by the varying per cent of clouds. A *dry* slip is exposed to the influences of these conditions, and a gradual deposition of the moisture upon the same aids rather than retards the coloration. But when a *moistened* slip is exposed to the influences of these conditions of the atmosphere, it is liable to become blanched as fast as the iodine is deposited. Cornelius B. Fox says: 'If the iodide of starch be so slightly soluble in water, how does it happen that these tests often and rapidly become, when they are wet, completely blanched? If a deeply tinted Negretti's test be cut into small portions and placed in a little distilled water, some difficulty will be experienced in rendering the fragments colorless. Many hours, and perhaps a day or two, will elapse before all color is removed from them. If, on the other hand, a colored Negretti's test be kept in a moist condition with distilled water, conducted to it by a fine thread of lamp-wick or darning-cotton, the color will rapidly disappear. In the latter experiment the iodide of starch becomes vaporized from the test.'

"It is thus proved that in more than one-fourth of the cases where observations are taken with Schönbein's test, providing the same proportion of days all cloudy existed as above illustrated, the dry slip will exhibit the greatest coloration, and in the remaining cases the deepest tint would be exhibited by means of the wet slip.

"Through the kindness of a friend residing in Litchfield County, of the state of Connecticut, I was enabled to secure results of ozonometric observations among its non-malarious hills, during the summer of the year 1878. The record of these observations is presented in the following exhibit in comparison with the record of observations taken at this point, where periodic fevers prevail:

"The small quantity of ozone exhibited for the night in the record obtained from Connecticut impresses one with the belief that some atmospheric conditions existed that failed to testify to the actual amount of ozone present. Excessive moisture appears to have been one of these conditions, as reported by the observer to me.

"As local conditions greatly affect the test for ozone, the observations that might be taken in other parts of this mountainous country might present results more in unison with the popular belief that active oxygen exists in greatest quantities amidst the mountains.

"As spoken of, the velocity of the wind, if it is great, and the air is saturated with moisture, will occasion a decolorization of the test-paper unless protected from its influence. But if a test-paper be exposed to the free action of the wind when the air is not saturated with moisture,

EXHIBIT I.

Date, 1878.	Lichtfield County, State of Connecticut		Otisville, Michigan.		Date, 1878.	Lichtfield County, State of Connecticut.		Otisville, Michigan.	
	Night.	Day.	Night.	Day.		Night.	Day.	Night.	Day.
Aug. 6	4	5	3	3	Sept. 9	0	2	4	2
" 7	4	4	3	3	" 10	0	3	2	3
" 8	3	3	3	4	" 11	0	4	2	2
" 9	4	6	3	4	" 12	2	3	..	3
" 10	4	4	3	4	" 13	1	3	4	4
" 11	3	4	1	1	" 14	0	2	4	1
" 12	3	4	*0	3	" 15	2	3	1	2
" 13	1	3	3	3	" 16	0	2	5	3
" 14	0	2	4	3	" 17	0	3	2	3
" 15	0	3	4	3	" 18	0	3	3	3
" 16	2	3	4	3	" 19	..	3	..	3
" 17	2	3	1	3	" 20	2	2	3	4
" 18	2	4	1	3	" 21	1	2	3	3
" 27	0	3	†0	3	" 22	2	3	1	3
" 28	1	3	3	3	" 23	0	2	3	2
" 29	1	3	4	4	" 24	0	2	3	4
" 30	1	2	1	4	" 25	2	3	3	3
" 31	0	3	3	4	" 26	1	2	4	3
Sept. 1	3	2	3	2	" 27	3	2	§1	2
" 2	0	2	4	3	" 28	1	3	3	3
" 3	0	3	4	4	" 29	0	3	4	2
" 4	2	1	3	3	" 30	0	2	4	2
" 5	4	1	‡0	3	Oct. 1	0	2	3	1
" 6	2	3	‡0	3	" 2	2	3	4	3
" 7	0	2	4	4	" 3	3	3	3	2
" 8	1	3	4	2					
					Avr'ge	1.38	2.82	2 77	2.90

* Heavy dew in morning.
† Great amount of moisture in night.
‡ Fog in morning.
§ Frost in morning.

a greater coloration will often occur than when *protected* from the action of the wind.

COLORATION OF BOTH SIDES OF THE TEST-PAPER.

"Although Schönbein's test is considered the most reliable in use for the detection of ozone, something yet remains to be done in order to render even this test perfect, exclusive of the effects of such conditions as already have been mentioned.

"In the manufacture of the test-paper I use, only one side of it is covered with the preparation that by chemical alteration and change of color enables us to estimate the relative amount of ozone present. In this connection Dr. H. B. Baker remarks that 'some test-paper prepared in Germany, examined by me, seemed to be like Swedish filter-paper; it was of loose texture, and on exposure was soon colored on both sides alike, but the degree of coloration was more uniform under varying con-

ditions than it is on the paper used by the observers in Michigan. The loose texture paper seemed to be exceedingly prone to take on a color equalling from 2 to 4 on our scale, but did not seem to be as ready to show shades above or below those. On comparing it with our paper, it was found to fade quicker after being moistened, and I came to believe that it was not so accurate as is ours for the purpose of indicating the relative qualities of ozone in the atmosphere.' In examining the test-paper, after exposure, I have frequently found that the side of the paper upon which there was none of the preparation, exhibited the greater coloration. To determine, if possible, the cause of this, I recorded in a series of observations, as shown in the following exhibit, the degrees of coloration that appeared upon both sides of the paper. In the first series the number of observations was 34. In 19 of these observations there was the deeper coloration on the side not having the preparation on it. The same degree of coloration occurred upon both side at once in 13 instances. There was a deeper coloration on the side containing the compound of starch and iodide of potassium, twice.

"Assistant Professor F. S. Kedzie, of the Agricultural College, at Lansing, Mich., suggests that these conditions may appear from the existence of a thin film, or tough pellicle, sometimes formed over the starch compound, thus preventing the access and ready action of ozone in setting free the iodine; the degree of coloration varying according to the condition of the surface of the test-paper, and according to certain conditions of atmospheric humidity existing at the time of the exposure of the test.

"It is probably true that varying conditions of moisture have a marked influence with other influences producing the results referred to.

"In sixteen of the nineteen instances where there was a deeper tint on the back of the paper, the relative humidity was less than ninety per cent, ranging from fifty-three per cent upwards. In three instances where there was the deeper tint upon the back, the relative humidity exceeded ninety per cent. In only one instance did the relative humidity mount to one hundred per cent. In only three instances out of the fifteen when the front had a coloration equal to that upon the back of the test-paper, or a greater coloration, the relative humidity was less than ninety per cent. In twelve instances when the coloration upon the front was equal to, or greater than that upon the back, the relative humidity exceeded ninety per cent. In seven of the fifteen instances when the degree of coloration on the front was equal to, or greater than, that upon the back, the relative humidity was one hundred per cent. This would seem to prove that conditions of moisture have a decided influence in affecting the phenomena in question.

"After an exposure of the test-paper for a time sufficient to produce a coloration, if there is a deeper tint upon the back than on the front side, a removal of a thin portion of the starch from the front will not disclose

EXHIBIT K.

First Series of Observations on the Influence of Relative Humidity upon the Coloration by Ozone of Both Sides of the Test-Paper.

	Coloration, Marked on a Scale of 10°.		Relative Humidity.—Per Cent of Saturation of the Air at the Beginning of the Exposure when the Coloration was as Specified.			
	On Front of Test-paper.	On Back of Test-paper.	All Observations in the Series.	Greatest Color on Front of Paper.	Same Color on Both Sides.	Greatest Color on Back of Paper.
	2	2	82.3	....	82.3	....
	1	2	95.3	....	....	95.3
	2.5	3	95.3	....	.. .	95.3
	2	3	76.0	....	. ..	76.0
	2	3.5	84.2	....	....	84.2
	2.5	3.5	76.0	....	....	76.0
	2.5	3.5	74.9	....	....	74.9
	2.5	3.5	87.1	....	....	87.1
	1	2	100.0	....	....	100.0
	3.5	3	89.3	89.3	....	....
	1.5	2.5	81.4	....	....	81.4
	3.5	3.5	100.0	....	100.0	....
	3	3	100.0	....	100.0	....
	2	3.5	76.9	....	....	76.9
	2.5	2	100.0	100.0	....	....
	3.5	3.5	100.0	....	100.0	....
	2	3	53.7	....	....	53.7
	2.5	3.5	87.1	....	....	87.1
	2	2	93.2	....	93.2	....
	3	3.5	86.4	...	....	86.4
	3	4	85.8	....	....	85.8
	2.5	2.5	92.6	....	92.6	....
	3	3	92.8	...	92.8	....
	2.5	3.5	86.6	....	....	86.6
	2.5	3.5	93.1	....	....	93.1
	3	3.5	71.0	...	....	71.0
	3.5	3.5	100.0	....	100.0	....
	3	3	94.4	....	94.4	....
	3	3	100 0	....	100.0	....
	2.5	2.5	95.0	....	95.0	....
	3	3.5	85.8	....	....	85.8
	3	3	80.5	....	80.5	....
	1.5	2.5	69.4	....	....	69.4
	2.5	2.5	100.0	....	100.0	....
Total. ...	85.5	102.5	2986.1	189.3	1230.8	1566.0
Averages.	2.51	3.01	87.8	94.7	94.7	82.4

as deep a tint as there is upon the back, nor will as marked a coloration appear in front until all the starch is removed, when both sides of the paper exhibit the same degree of discoloration.

"The paper which is used in preparing the test readily absorbs a portion of the solution of iodide of potassium contained in the starch compound, and on exposure to oxidizing elements exhibits chemical change as well as the prepared starch. The difference in the texture of the

paper itself from the texture of the starch compound would suggest the existence, in the paper and compound, of differing qualities for the absorption of moisture.

"An *average* degree of moisture seems to be a condition rendering the paper saturated with a solution of iodide of potassium in starch-water a more delicate test than the starch and iodide of potassium test. Where *excess* of moisture obtains, the starch and iodide of potassium test appears to be the most reliable.

"The preceding exhibit does not contain an extensive series of observations as we would wish to have in order to establish conclusive evidence, but was all we had at the time of writing the foregoing. Since that time additional observations have been made, and the results are shown in the following exhibit (L).

"In the following exhibit (L), the statement of the relative humidity is made for the time when the test-paper was put out for exposure. In nearly all the cases where there was *less* coloration on the back of the paper than on the front, and a relative humidity of *less* than ninety per cent at the time the test-paper was put out, the relative humidity was over ninety per cent when the paper was compared with the scale, showing that there was an increase of moisture after the paper was first exposed.

"When the back of the paper was the most deeply colored, and on its first exposure the relative humidity was more than ninety per cent (another exception to the general rule), there was almost always a considerable decrease in the relative humidity.

SUGGESTIONS FOR IMPROVED METHODS OF OBSERVATIONS.

"Negative results obtained by the exposure of Schönbein's test-paper in dwellings seem to be due as much to elements affecting the liberated iodine as to absence of ozone. This test, then, seems to be of little use in determining the presence of ozone in dwellings.

"Valuable as are the general results of ozonometric observations, it is obvious that many of them are clouded with error. How to remove these errors is a subject important to all those interested in the study of ozonometry as to its meteorological, physiological, or pathological relations. Much study is yet necessary before the best methods for accurately estimating the quantity of ozone present at any time in the atmosphere will be determined. In the use of Schönbein's test, in order to obtain the maximum results of an observation where it is necessary to guard against excess of moisture, the exposure of a dry and wet slip at the same time would appear to be a proper method to adopt; also to suspend them at such points as where the condensation of vapor would be least liable to occur. To make the period of time less for the exposure of test-paper would be another means to obtain maximum results of an observation.

EXHIBIT L.

Second Series of Observations on the Influence of Relative Humidity upon the Coloration by Ozone of Both Sides of the Test-paper.

	Coloration, Marked on a Scale of 10°.		Relative Humidity—Per Cent of Saturation of the Air at the Beginning of the Exposure when the Coloration was as Specified.			
	On Front of Test-paper.	On Back of Test-paper.	All Observations in the Series.	Greatest Color on Front of Paper.	Same Color on both Sides.	Greatest Color on Back of Paper.
	3.5	3.0	100.0	100.0	....	....
	3.0	3.5	85.8	....	....	85.8
	3.5	4.5	75.5	....	....	75.5
	2.5	3.0	86.2	....	....	86.2
	1.5	3.0	83.4	....	....	83.4
	4.0	4.0	100.0	....	100.0	....
	3.5	3.0	100.0	100.0	....	....
	5.0	4.0	91.3	91.3	....	....
	3.5	2.0	85.8	85.8	...	....
	2.0	3.0	74.5	....	74.5	....
	2.0	3.5	75.9	....	....	75.9
	3.0	3.0	84.0	....	84.0	....
	3.0	3.0	91.4	....	91.4	....
	3.5	4.0	83.4	....	....	83.4
	3.0	2.5	83.4	83.4	....	....
	7.0	3.0	93.1	93.1	....	....
	3.0	2.0	100.0	100.0	....	....
	8.0	3.0	91.4	91.4	....	....
	3.0	2.5	91.6	91.6	....	....
	4.0	2.5	100.0	100.0	....	...
	3.0	2.5	100.0	100.0	....	....
	3.0	3.0	90.6	...	90.6	....
	2.5	4.0	100.0	....	....	100.0
	3.5	3.5	100.0	....	100.0	....
	4.0	4.5	79.3	...	....	79.3
	2.5	2.5	92.6	....	92.6	....
	2.5	3.0	84.0	....	....	84.0
	3.0	3.0	100.0	....	100.0	...
	4.0	3.0	92.6	92.6	....	....
	2.0	3.0	79.3	....	....	79.3
	2.5	3.0	69.6	....	....	96.6
	3.5	2.5	93.2	93.2	....	....
	3.0	3.0	100.0	....	100.0	....
	4.0	3.5	92.6	92.6	....	....
	3.5	3.5	100.0	....	100.0	....
	8.0	6.0	100.0	100.0	....	....
	6.0	5.0	90.5	90.5	....	....
	3.5	2.5	100.0	100.0	....	....
	3.0	4.0	83.4	....	....	83.4
Totals. ...	139.5	128.5	3524.8	1605.5	933.1	986.2
Average.	3.58	3.29	90.4	94.4	93.3	82.2
Av. of both ser.	3.08	3.16	89.2	94.5	94.1	83.2

"It is well known that by increased velocity of the wind more ozone may be carried to a given point than there would be if the velocity were less. To determine the quantity of ozone, therefore, liable to affect the

health of an individual subjected to the influence of rapid currents of air, it is desirable to expose the test-paper to the same current. But the loss of the liberated iodine, as a result of such exposure, suggests that in order to obtain the deepest coloration the slip must be protected from too great velocity of the wind, especially when there is an excess of moisture in the atmosphere."

NITROGEN is a colorless gas without taste or smell, rather lighter than common air: its specific gravity being 0.972. It is slightly soluble in water, and distinguished by its apparent want of properties. It will neither support life nor combustion. A burning taper is instantly extinguished in this gas, and an animal soon dies in it, not because the gas is injurious, but from the privation of oxygen. Yet it forms four-fifths of the bulk of the atmosphere, and enters into the composition of all organic bodies—not, however, always found in vegetable substances, though it is well known that no plant can attain maturity without the presence of matter containing nitrogen. But no animal body which possesses motion is destitute of it. It is an essential element of food for all the purposes of nutrition, and the chief ingredients of human blood contain nearly seventeen per cent of nitrogen. Yet it seems to take no other part in the functions of life than mere presence, the vital processes requiring this, however, for their healthy exercise.

When the mysterious principle of life has ceased to exercise influence, nitrogen assumes a peculiar activity, and becomes a promotor of death and decay, by escaping from the elements which have held it in abeyance. Its utility now becomes manifest. Nitrogen is emphatically the element of death bound up with the life of the organism of every living being. During life it is subject to the control of the vital forces, but no sooner does life cease than nitrogen acquires a strong affinity with hydrogen, and combining with it forms a new compound—*ammonia.* Oxygen is thereby disengaged, and a new set of affinities begins, converting what would otherwise be a state of rest into one of commotion and change. Fermentation is excited, decomposition and oxidation proceed uninterruptedly to a complete transformation of organic matter back again into its original elements.

CHAPTER IV.

VARIABLE CONSTITUENTS OF THE ATMOSPHERE.

AMMONIA, CARBONIC ACID, MOISTURE AND ELECTRICITY; AND FLOATING MATTER IN THE AIR.

NATURE AND SOURCES OF AMMONIA—ABUNDANCE AND PROPERTIES—INDICATIONS—PUTREFACTION AND ITS RESULTS—TESTS; CARBONIC ACID: NATURE, SOURCES, PROPERTIES, DIFFUSION, DANGERS AND TESTS OF; MOISTURE: QUANTITY AND PROPORTION IN THE ATMOSPHERE AT TEMPERATURES—ABSOLUTE HUMIDITIES; ELECTRICITY; FLOATING MATTER IN THE AIR.

1. AMMONIA.

AMMONIA is a very light, colorless, gaseous compound, which consists of one equivalent of nitrogen and three equivalents of hydrogen. Its specific gravity or relative weight, when compared with hydrogen, the lightest of all gases, is 8.5, or a little more than half that of the weight of atmospheric air. It possesses a strong and pungent odor, familiar in spirits of hartshorn, and is distinguished as the volatile alkali. It exists normally in the proportion of about three and a half volumes in every 10,000,000 of atmosphere. In other words, in ten million gallons of pure atmosphere, the amount of ammonia gas present is, on an average, not more than three and a half gallons; though it frequently exceeds this, and wherever it exists in excess it is suggestive of impure local conditions.

Ammonia is exceedingly soluble in water, and cannot, therefore remain long in excess in the atmosphere, especially in rainy places, as every shower of rain condenses it and conveys it to the surface of the earth. Hence, rain-water always contains more or less ammonia, and it is this which gives to rain-water the apparent sensation of *softness* generally experienced in its use.

In an address on "Air as a Sanitary Agent," delivered to the Sanitary Institute of Great Britain, at Glasgow, in September, 1883, by Dr. R. Angus Smith, the celebrated author of "Air and Rain," the following practical remarks are made in regard to ammonia:

"When a room is shut up even for a day, unless the room be very

large indeed, there is always that peculiarity observed by sensitive persons to which would be given the name of closeness. Yet there are people who do not seem to observe this, and who spend their lives in rooms in which this closeness may be constantly observed. I have often reflected on this peculiar condition. Surely, if oxygen removed all impurities, these impurities ought to have been removed, since the oxygen of the air is never absent from the rooms, except to such a small extent that the estimation of the change is extremely difficult. If we lift up a window and allow the air to blow into the room so as to entirely replace the original air, we do not at all times attain efficient aëration. It takes but a few minutes, in a climate where there is considerable motion in the air, to renew the atmosphere of a room entirely; we may judge of this by making a trial upon a visible atmosphere, viz., one pretty well-filled with smoke. We see how rapidly with an open window every trace may be removed from the farthest corner, and yet this new air is not sufficient to refresh the room, and closeness is the characteristic still complained of. It is the custom in well-regulated houses not to renew merely the air, but to cause the air to blow through the house for a considerable time every day when the weather permits it. Knowing this for a long time, I wondered very much what was the reason. Surely, I said, there was vital air enough without the long-continued current.

"Then the remarkable discovery of Schönbein came to my mind, as I suppose it has to the minds of many other chemists, and I thought it must be the ozone in the air that does the work, and as there is little ozone in a volume, the air requires many repetitions of bulk. There may be some truth in this still; but whether the air receives imperfect contact with the substances to be purified, whether the mechanical action of the current is necessary, or some other cause, it is certain that a continual current is necessary for perfect purification. Looking further at this subject, it occurred to me that really clean houses were preserved in this condition by something more than currents of air generally, and that good housewives resorted to the practical method of rubbing by hand, and it seemed clear that no furniture could be preserved from that peculiar condition of mustiness in any house where the doors and windows must be frequently closed, unless the absolute removal of certain substances from the surface were resorted to. And what was this substance that required to be removed? I suppose it to be one of organic origin.

"If organic matter is everywhere, the presence of ammonia is everywhere possible; and if that matter is decomposing, ammonia is everywhere. That is the general statement which this paper illustrates. It is now many years since it was observed by me that organic matter could be found on surfaces exposed to exhalations from human beings; but it is not till now that the full significance of the fact has shone on me, and the practical results that may be drawn from it in hygiene and mete-

orology. These results are that ammonia may be an index of decayed matter. The idea has been used partly and to a large extent—as illustrated in my 'Air and Rain;' the facts now to be given enable us to claim for it a still more important place. The application seems to fit well the conditions already examined; and by this means currents from foul places have been readily found. This does not apply to the substances which may be called germs, whether it be possible to see them or not, because they are not bodies which have passed into the ammoniacal stage, although some of them may be passing—those, for example, which are purely chemical and exert what we may call *idiolytic* action.

"Ammonia must ever be one of the most interesting of chemical compounds. It comes from all living organisms, and is equally necessary to build them up. To do this, it must be wherever plants or animals grow or decay. As it is volatile, some of it is launched into the air, on its escape from combination; and in the air it is always found. As it is soluble in water, it is found wherever we find water on the surface of the earth, or in the air, and probably in all natural waters, even the deepest and most purified. As a part of the atmosphere it touches all substances, and can be found on many; it is in reality universally on the surface of the earth in the presence of men and animals, perhaps attached more or less to all objects, but especially to all found within human habitations, and we might also add, with equal certainty, the habitations of all animals.

"If you pick up a stone in the city, and wash off the matter on the surface, you will find the water to contain ammonia. If you wash a chair or a table, or anything in the room, you will find ammonia in the washing; and if you wash your hands you will find the same; and your paper, your pen, your table cloth, and clothes all show ammonia; and even the glass cover to an ornament has retained some on its surface. You will find it not to be a permanent part of the glass, because you require only to wash with pure water once or twice, and then you will obtain a washing which contains no ammonia; it is only superficial.

"This ammonia on the surface is partly the result of the decomposition, continually taking place, of organie matter adhering to everything in dwellings. The presence of organic matter is easily accounted for; but it is less easily detected than ammonia. It is probable that the chief cause of the presence of ammonia on surfaces in houses and near habitations is the direct decomposition of organic matter on the spot. If so, being more readily observed than organic matter itself, it may be taken as a test, and the amount will be a measure of the impurity. A room that has a smell indicating recent residence will, in a certain time, have its objects covered with organic matter, and this will be indicated by ammonia on the surface of objects. After some preliminary trials, seeing this remarkable constancy of comparative results and the beautiful gradations of amount, it occurred to me that the same substance must

be found on all subjects around us, whether in town or not. I therefore went a mile from the outskirts of Manchester, and examined the objects on the way. Stones that not twenty hours before had been washed by rain showed ammonia. It is true that the rain of Manchester contains it also; but, considering that only a thin layer would be evaporated from these stones, it was remarkable that they indicated the existence of any. The surface of wood was examined; pailings, railings, branching of trees, grass (not very green at the time), all showed ammonia in no very small quantities. It seemed as if the whole visible surface around had ammonia. I went into the houses and examined the surfaces in rooms empty and inhabited, tables, chairs, walls, plates, glasses, and drawing-room ornaments. A (Parian) porcelain statuette under a glass showed some ammonia; a candlestick of the same material (but uncovered) showed much more. The back of a chair showed ammonia; when rubbed with a common duster, there was very little. It seemed clear that ammonia stuck to everything.

"If, then, ammonia was everywhere, the conclusion seemed to be that it was not at all necessary to do as I had been doing, namely, wash the air so laboriously; it would be quite sufficient to suspend a piece of glass, and allow the ammonia to settle upon it. For this purpose small flasks were hung in different parts of the laboratory, and examined daily. The flasks would hold about six ounces of liquid, but they were empty, and the outer surface was washed with pure water by means of a spray bottle; it was done rapidly, and not above twenty cub. centim. (two-thirds of an ounce) of water was used. This was tested for ammonia at once with the Nessler solution. The second washing, taken immediately, produced no appearance of ammonia. Ammonia could be observed after an hour and a half's exposure at any rate; but I do not know the shortest period.

"To me it seemed perfectly clear that the character of closeness was connected with the existence of organic matter, and the organic matter with the ammonia. That ammonia should be found almost everywhere, but in small quantities, was not to be wondered at, considering the universal presence of organic matter in the air and waters of the world. It was when considering these things, the effect of oxygen on this organic matter, that I came to the conclusion that a current of air either carried away the organic matter with it, decomposing it and turning it into gases, or, if it were not possible for oxygen alone to do this, it might happen that the oxygen destroyed those minute forms which have been shown to be concomitant with putrefaction and decay. . . .

"As putrefaction seems not to take place without the action of organisms, I had the idea that it might be arrested by an abundant use of air, and I had some belief that the oxidation took place very rapidly after putrefaction. It was when examining this subject that I found it necessary to touch also upon the question of nitration in water. When

nitrôgenous bodies decompose with an abundance of oxygen, the nitrogen becomes oxidized, and nitric acid is formed. I had long suspected the reverse also took place, and that when there was an excess of putrefactive matter oxygen was absorbed, and even removed from the nitrate, whilst free nitrogen was given off. This process I was able to verify by carrying it into the laboratory. It was clear then, and beyond all cavil, that rivers could purify themselves in time, and organic matter be thoroughly removed. It was clear that organic substances, that germs of disease, that microbes, and the smallest organisms themselves were all subjected to this universal and unsparing attack of putrefaction and oxidation.

"Putrefaction destroys organic matter without the influence of oxygen; it breaks up organic compounds, and destroys organisms. The evidence seems to indicate that it destroys those bodies that produce disease, but that in certain conditions it produces others. This is a point not to be enlarged upon without more knowledge, but it is evident that by putrefaction we get rid of an enormous amount of offensive matter. Oxygen cannot enter under the surface of actively putrefying bodies; but wherever it is allowed to enter by the putrefaction being less active, an action begins which in time completes the destruction of the body. We are not therefore to suppose that the germs of disease can resist all these efforts of nature to destroy noxious things, nor are we to suppose that an invisible germ can pass from stage to stage unaffected by the putrefaction of sewage and the action of air. We must believe, for the present, that it is not so. In water we see perfect putrefaction, nitrogen itself being lost.

"In ordinary putrefaction sulphuretted hydrogen comes off in abundance, with much carbonic acid and some nitrogen. Oxygen resists this action, and if this action is applied in a concentrated condition a change takes place; nitrogen is evolved as the principal gas, and a decomposition of nitrogenous compounds takes place. Nitrogenous bodies are thus destroyed in one manner by their voluntary putrefaction, in another by oxidation. . . .

"Putrefaction and oxidation are two well-known modes of destroying organic bodies at ordinary temperatures. The second (oxidation) is not proved to be connected with organisms. How far, then, can oxidation, or a great supply of air, be employed to destroy putrefaction or to purify?

"The bearing it has on the analysis of water will be clearly seen by chemists. The bearing on the sewage question is also interesting. Substances and living things may be carried by the rapid sewage system into the range of a new activity before undergoing the putrefaction which breaks them up in proximity to us or in the sewers themselves. It seems to point to a plan of causing the destruction of organisms by putrefaction and subsequent oxidation or chemical action. At

least it seems to me that we require to learn if it be true that any of the germs of disease, or which germs of disease, will live in an abundance of good air. We know that abundant dilution will render them all ineffective. It is probable that there will be a difference amongst them in this respect, whilst all will yield to the double action of, first, putrefaction, and then oxidation. . .

"It has often been asked, what will become of those many poisonous emanations which arise from the human body in health, and from those still more dangerous substances which are generated within it during many of the multifarious diseases to which man is subjected. The germ theory of disease has caused alarm in many directions, and it has been imagined that some little germ of disease passing into a sewer or pure river might carry with it power to infect other organisms to such an extent that there was reason to fear for the lives of all the inhabitants on its banks. This extreme application of a theory might not be unreasonable were it not that we know from results that no such power exists in any of those germs known to us.

"Let us consider the number of polluted liquids which pass from the houses and hospitals of such a city as Glasgow, and the fact that so many of its inhabitants go down to the banks of the Firth, towards which the waters of the Clyde flow, and receive there health and strength for themselves and their families, and we shall see how absurd the ideas have been concerning the power of individual germs, or even multitudes of germs in such situations. . . .

"It is remarkable how rapidly sewage enters into putrefaction; and to know the results of this putrefaction has been a considerable difficulty. The gases from sewers have been found to produce a peculiar form of fever, very well known to medical men in some of its stages, and apparently so definite that it may be considered as ranking with one of the chemical tests in its strictness. The gases which come from it are the results of the decomposition of organic matter, and the number of compounds into which the material of animals may be broken up is so varied that at present it may be said to be entirely beyond our ken. These compounds vary in character to such a degree that they may form the most innocent gases, the most wholesome food, or the most virulent poisons, venomous substances that destroy entirely vital functions of the human body in a scarcely appreciable time. Some of these obnoxious bodies arise from the decomposition of sewage, and, as already said, seem to be formed at some particular proportion of the supply of air.

"It is easy to see that it is a mistake to suppose that by sending putrefying liquids down to lands we are giving these lands all the substance which the sewage originally contained. If we wish to use them as sewage it is better to use them before putrefaction, the loss by putrefaction being great. I suppose we can scarcely doubt that putrefaction

takes place more rapidly when the organic matters are diluted to a very considerable extent with water.

"Having made many experiments in order to find the condition of the air found lying over somewhat solid putrid substances compared with the same substances very diluted with water, it was found that the greatest amount of ammonia and the most offensive odors were from the more solid. This is quite in accordance with the explanation given of the more complete disruption of the organic matter in water, and it was these experiments that led me first to think of driving the air through sewage matter in order to produce oxidation, expecting readily to form nitrates, and in the belief also that the excess of air would be offensive to the microzymes, although a small amount seemed necessary for their activity. . . .

"The result of the aëration of sewages, and of other liquids containing organic matter to a similar extent, was, that in all cases putrefaction was delayed by aëration. The dissolved oxygen also recovers itself in the aërated specimens better than in the non-aërated. This shows that aëration not only prevented putrefaction, but prevented also the chemical action consequent upon it. It had, in fact, to a large extent, and for a considerable time, rendered the organic matter inert, or nearly so. Nitrates are formed also more readily in the aërated than in the non-aërated specimens.

"It was in looking for nitrates and measuring the amount of ammonia in the aërated and non-aërated solutions that I observed how much the ammonia diminished in amount, and sometimes the air passing out from the water contained a strong smell of ammonia. The sewage was tossed about, the volatile matter carried up with the currents of air, and had no opportunity of returning. Work of a similar kind has been done by Monsieur Lauth, which has been published in the *Comptes Rendus*, where the following is stated:

"'It is well known that to obtain the ammonia from sewage has been the aim of chemists for many years; and to make use of it in some form or other without extracting it, has been the study of many engineers. The amount of ammonia, as we have long known, is great in sewage, but we have not known how to remove it. The amount, however great in bulk, is small indeed in proportion to the amount of water, being from four to seven grains, very often not more in a gallon of 70,000 grains. The loss of ammonia, when using the apparatus described, suggested at once a method of obtaining a revenue from sewage.'

"The results obtained are far greater than those obtained by me, and the product increase of ammonia by putrefaction is remarkably so.

"If we could only take one grain of ammonia out of one gallon sewage we should have from 1,000,000 gallons 1,000,000 grains: 142.8 lbs., let us say 140 lbs. Let us suppose there are in Glasgow flowing from the sewers daily 50,000,000 gallons, and we should have 7,000 lbs. am-

monia daily, this would give us in a year above 1,100 tons, which might be put down as somewhere nearly £60,000."

Such estimates as this serve to suggest the immense importance of ammonia in the life of the world. It is by ammonia that plants everywhere are supplied with nitrogen—without which they cannot exist. They are supplied chiefly from the atmosphere by the rains, mists, and dews; and by manures of all kinds whose value is in proportion to the amount of ammonia they contain.

The amount of ammonia found in different waters is (in weight):

Rain-water	0.0000008
Fresh water (reservoirs, etc.)	0.0000002
Spring-water	0.0000001

Sea-water, from one to two grains for every cubic foot. Trifling as this quantity appears to be, when we reflect that the ocean covers more than three-quarters of the globe, and consider its enormous mass, it may be looked upon as the vast reservoir of ammonia whence the atmosphere can make good the losses which it is continually undergoing.

M. Desfontains, a distinguished French engineer, some years ago estimated the amount of ammonia carried down to the sea by the Rhine. He computed that the Rhine at Lauterburg has, on the average, a flow of 39,000 cubic feet of water a second. From a careful analysis of the water, in its passage by Lauterburg, it carries down with it every twenty-four hours at least 22,500 lbs. of ammonia—that is, 13,000,000 lbs. a year. Taking this estimate as a fair example of the amount of ammonia poured into the sea by the rivers of the world, in proportion to the volume of the water-flow severally, the mind fails to comprehend the magnitude of the amount of ammonia and the waste of agricultural wealth poured into the sea by the outfall of sewers.

Minute traces of free ammonia or ammonium compounds may be detected: (1) by Nessler's solution—an alkaline solution of potassium-mercuric iodide.[1] When a few drops of this solution are added to a dilute solution containing ammonia or a salt of ammonium, a reddish-brown precipitate or corresponding color is at once produced. In this way it is possible to detect $\frac{1}{300}$ of a milligram of ammonium chloride dissolved in 50 c.c. of water. (2) By turning vegetable blues green, and vegetable yellows brown; but which soon regain their previous colors, especially on the application of heat. (3) By producing dense, white

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[1] *Nessler Test:* 500 grains of iodide of potassium are dissolved in a small quantity of hot distilled water, and to this is gradually added a cold saturated solution of mercuric chloride (corrosive sublimate), till the precipitate produced ceases to be dissolved upon stirring. To render this alkaline, add 2,000 grains of hydrate of potassium and dilute the volume to 10,000 grain measures. A little more saturated solution of mercuric chloride is added, and the whole allowed to settle, and the clear liquid decanted off. The test should have a slightly yellowish tint. If colorless it is not sensitive, and more mercuric chloride must be added.

fumes when brought in contact with the fumes of hydrochloric acid. (4) If a saturated solution of arsenious acid is mixed with a solution of nitrate of silver (two per cent) a trace of ammonia causes the formation of argentic arsenite. (5) Böttger says an aqueous solution of carbolic acid is a very delicate test; that, on adding to a liquid containing the smallest quantity of ammonia, or ammoniacal salt, a few drops of this solution, and then a small quantity of a filtered solution of chloride of lime, the liquid becomes green, especially when warm.

2. CARBONIC ACID.

This gas is like oxygen and nitrogen in being devoid of color, but unlike them in that it possesses a slightly pungent odor and a perceptible sour taste. Moreover, it is not a simple substance, but, like ammonia, a compound, and contains two elements: oxygen and carbon; and, like ammonia, also, in that it may exist in variable proportions in circumscribed places. It is always produced when carbon in any form, or any compound of carbon, is burnt with a free supply of air; and is continually given off by man and the lower animals in the process of respiration. It is non-inflammable and irrespirable; an animal immersed in it dies instantly. Even when greatly diluted with air, it cannot be inhaled for any length of time without insensibility following. An atmosphere containing more than its natural quantity (about four volumes in every ten thousand, or one part in every twenty-five hundred parts by measure), acts upon the system as a narcotic poison, hence the danger of overcrowded and unventilated rooms. It is a non-supporter of combustion, at once extinguishing a lighted candle, gas-jet, or even a piece of burning phosphorus when these are placed in a jar of it. Water absorbs its own volume of carbonic gas, and by pressure may be made to take up enormous quantities, forming carbonated or aërated water. It is evolved in considerable quantities from clefts in the earth and caves; and is particularly abundant in the neighborhood of volcanoes. It is widely distributed in nature, both free and combined with various bases; and is everywhere the food of plants. Without carbonic acid, vegetation cannot exist, and it is by the absorption of carbonic acid by plants that the equable proportion of it in the atmosphere is maintained.

The weight of carbonic acid, as compared with the other gases of the atmosphere, is about one-half greater: specific gravity, 1.520. This fact suggests, at first thought, that carbonic acid ought always to be found in larger proportion at the surface of the earth and nearer the floors of unventilated buildings than the ceilings. But the truth is, that although carbonic acid is the heaviest gas of the atmosphere, it is quite as abundant in the air at the greatest elevation at which it has ever been examined as it is at the surface of the earth. This is due to the natural law of gases, called *gaseous diffusion: That all gases tend to diffuse themselves through each other.*

The law of gaseous diffusion is promoted by the wind, but it will operate in a confined place; insomuch that even in crowded rooms, especially if they are warm, carbonic acid is frequently found more abundant at the ceiling than it is at the floor.

If certain liquids of different densities be commingled, such as oil and water, they separate again immediately that they are left at rest. But gases of different densities, when brought together, immediately begin to intermix and thoroughly incorporate themselves with one another, and they never separate when left at rest.

In like manner all the gaseous substances of, and in the air, in conformity to the law of gaseous diffusion, have a constant tendency to interfuse and incorporate themselves as a homogeneous mixture of uniform proportions over the whole surface of the earth. Carbonic acid fails in its conformity to this law only where it is generated and restricted; as in grottos, mines, wells, and crowded unventilated houses and vessels. In such places it is liable to accumulate manifold its proportion in the atmosphere, and to a fatal extent.

Dr. R. Angus Smith has shown that in towns the oxygen in the atmosphere is not less than in country districts, and that carbonic acid is often slightly in excess. This is shown in the following table :

IN MANCHESTER.

OXYGEN.	Per 1,000 Vols.	CARBONIC ACID.	Per 1,000 Vols.
In fog and frost	209.000	Streets	0.403
Outer circle, not raining	209.407	Where fields begin	0.369
Suburb in hot weather	209.800 209.600	Streets in fog	0.679

IN LONDON.

OXYGEN.		CARBONIC ACID.	
Open places, summer	209.500	On Thames	0.343
Streets, November	208.850	Parks, open	0.301
		Streets	0.380

M. Reiset obtained from a year's observations, at a station in the country far from dwellings, situated about four miles from Dieppe, an average of carbonic acid in the atmosphere of .2942 per 1,000. The air above a crop of red trefoil in the month of June gave .2898 per 1,000; and at a height of one foot from the soil in a barley-field in July, .2829 per 1,000. The corresponding amounts at the country station being .2915 and .2933 per 1000 respectively. The presence of 300 sheep near the apparatus raised the proportion to .3178 per 1,000. At Paris in May, 1873–75–79, the mean amount was .3027 per 1,000. In a leafy coppice the amount, however, was .2997 volumes in 1,000 of the air, as against .2902 volumes in the open. This difference between the coppice and the open may be due to the diminished quantity of light in the coppice. Messrs.

Müntz and Aubin found in Paris, near the Conservatoire des Arts et Métiers, at about twenty feet above the ground, that the quantity of carbonic acid varied from .288 to .422, whilst in the open country extending towards Grabelle, in the vicinity of Paris, the amount was nearly constant at .27; and on the Pic du Midi they found a variation of from .28 to .30.

It is evident that where people and animals are assembled in great numbers, and the various processes of combustion are being carried on out of the influence of vegetation, as in large cities, there may be occasions, as in calm weather, when carbonic acid accumulates temporarily to an inordinate extent. That it does not frequently, is due to the law of diffusion, and the winds.

According to the experiments on the diurnal variations of carbonic acid in the air by Saussure, Truchot, and Armstrong, the following are the general conclusions

1. That the normal amount of carbonic acid present in the air of the country is distinctly less than that usually stated, and that it does not exceed .35 volumes in 1,000 of air.

2. That plants absorb carbonic acid during the day, and exhale it at night, and that vegetation, therefore, affects the quantity of carbonic acid present in the air, decreasing it by day and increasing it at night.

That from this cause there is, during that part of the year when vegetation is active, at least ten per cent more carbonic acid present in the air of the open country at night than during the day.

In confined spaces, occupied by numerous persons, as before observed, carbonic acid accumulates in excess. It had been found in dormitories, public halls, theatres, schoolrooms, etc., in various poisonous amounts —from .45 to .72 per 1,000 volumes.

As a test for carbonic acid in excess, nothing is better than lime-water. This is readily made by pouring rain-water or distilled water into a bottle containing some lime just slaked, shaking the mixture well, and then allowing the lime to settle. The clear liquid contains a portion of the lime in solution, and this may be poured off into clean dark glass or covered bottles, and kept well stoppered for use. Exposure to air and light spoils it. Carbonic acid is absorbed by the lime, and the causticity of the lime is proportionally diminished; and moreover, on exposure of the lime-water to air containing an excess of carbonic acid, it speedily becomes almost milk-white. This is readily perceived by exposing a small quantity of the lime-water in a basin, or pouring it two or three times from one vessel into another in a room surcharged with the acid. By blowing into lime-water through a tube, or into a bottle of it, and shaking it a few times, it is also made white. This shows that the breath as it escapes from the lungs is loaded with carbonic acid, and unfit to breathe again until the excess of carbonic acid is gotten rid of by ventilation.

3. MOISTURE.

The moisture constantly circulating through the atmosphere is estimated to amount to the enormous quantity of 90,000 cubic miles of *water* yearly. This is raised by the sun's rays in the state of vapor from the surface of the ocean, lakes, rivers, and earth; and expanding more and more as it rises, it is distributed by the winds, insomuch that the atmosphere is everywhere more or less steeped in moisture, which, after washing the air and becoming charged with the foods of plants and other emanations from the surface of the earth, returns again as the morning due or the refreshing rain.

Moisture has a powerful affinity for organic matter in process of decay, which it tends to retard and diffuse, and by this means promotes the contamination of the atmosphere in the presence of such matter everywhere. Hence in estimating the relations of atmospheric humidity, the conditions of the locality should always be considered.

The amount of aqueous vapor *retained* in the atmosphere varies with the temperature, over the ocean and the land, the amount of vegetation, the altitude, geographical position, the seasons, etc. But at the same temperature and under the same pressure, the maximum quantity capable of being mixed with the air is invariable. It is rarely less than $\frac{1}{200}$, or more than $\frac{1}{60}$ of the volume of the atmosphere, and gives a mean ratio of 0.84.

Table showing the Absolute Humidity of Weight of Vapor in Troy Grains, in a Cubic Foot of Saturated Air at the Stated Temperatures of Fahrenheit:

Temperature of air	Vapor in grains	Temperature of air	Vapor in grains	Temperature of air	Vapor in grains
0°	0.545	63°	6.361	80°	10.949
5	0.678	64	6.575	81	11.291
10	0.841	65	6.795	82	11.643
20	1.298	66	7.021	83	12.005
30	1.968	67	7.253	84	12.376
32	2.126	68	7.493	85	12.756
40	8.862	69	7.739	86	13.146
45	3.426	70	7.992	87	13.546
50	4.089	71	8.252	88	13.957
55	4.860	72	8.521	89	14.378
56	5.028	73	8.797	90	14.810
57	5.202	74	9.081	91	15.254
58	5.381	75	9.372	92	16.709
59	5.566	76	9.670	93	16.176
60	5.756	77	9.977	94	16.654
61	5.959	78	10.292	95	17.145
62	6.154	79	10.616	96	17.648

The hygrometric state of the atmosphere, for a given temperature, represents the relation between the quantity of a moisture really therein

existing, and the quantity which would exist if the atmosphere were saturated at the same temperature.

The amount of moisture retained by the atmosphere at different degrees of temperature is shown by the foregoing table from the Smithsonian reports, by Professor Guyot.

4. ATMOSPHERIC ELECTRICITY.

Atmospheric electricity, according to the most recent investigations, is produced—

"1. (In general) by the friction of the air, humid or dry, upon the surface of land or of water.

"Everybody knows Armstrong's hydro-electric machine. We know that when the steam issues from the heater, the latter remains negatively charged, while the vapor is positively charged. This machine includes a box filled with water to cool the escape tubes. The steam before reaching the exhaust pipes experiences thus the commencement of condensation, and issues mixed with air vesicles. It is a necessary conditien.

"According to the experiments of Faraday, the passage of dry vapor or of a current of dry air does not produce electricity, while a current of humid air gives the same result as Armstrong's machine, but to a less degree.

"It is true that Spring found, on the contrary, that the friction of dry air upon a ball of copper gives a little electricity; but in an incomparably less quantity than in the experiment of Faraday. On the other hand, numerous experiments have proved that the evaporation alone of water, even acidulated, does not produce electricity.

"But in the evaporation produced by the wind, there is also friction. It is in this last mechanical work that the looked-for source resides.

"The wind in skimming the surface of the water carries watery particles from the crest of the waves, which play here the part of the comb of Armstrong's machine. The roughness of the soil plays the same part, when a damp wind passes over it.

"These molecules of water remain electrified and ascend into the atmosphere to form clouds, and as electricity lies at the surface of bodies, it tends to spread over the most elevated atmospheric surfaces, and I think with M. Faye that the cirri must retain a great portion of this electricity.

"Is there not a striking analogy between these laboratory experiments mentioned above, and the immense operations of the natural forces?

"2. (In Storms) the above being granted, we can conceive that a cloud will be electrified if formed under the conditions above mentioned. (It will not be same as a cloud which is formed by simple vapor rising in the morning into the atmosphere.)

"But in order that lightning be produced, there must be a discharge between the cloud and another point (earth or cloud) such that the difference of potential between the point and the cloud, existing at the moment considered, be sufficient to produce the lightning in question.

"Now the distance at which the spark strikes depends on the electric pressure and on the mechanical resistance that the medium opposes to the discharge. This pressure varies with the square of the potential of the cloud, its form, its surface, the discharge of the cloud, and its distance from the point specified.

"Now, the potential energy of a cloud depends upon its form, its surface, and its temperature. When the primitively electrified cloud experiences a transformation of any kind, condensation, congelation of the aqueous vesicles, etc., it absorbs a certain quantity of energy, which must be found again under the form of an augmentation of potential energy.

"This consequence results from the principle of the conservation of energy, and from the principle of M. Carnot, of which M. Lippman has taken such a remarkable advantage.

"If, then, we suppose that the charge of electricity of a cloud remains constant during a certain time, any condensation or decrease of temperature will augment the potential of its mass.

"When a storm bursts, it is rarely without electric manifestations. The abundant condensation which may be remarked becomes the cause of the augmentation of the potential of the storm mass, and when this potential is sufficient there is a discharge in the form of lightning. Besides, the continual renewal of the charge indicates that the cause resides in the storm phenomenon itself.

"3. (In heat lightning) the air being dielectric, the vapor becomes the natural reservoir of electricity. Suppose a mass of vapor of water electrified in suspension in the atmosphere. In the evening when the sun disappears, there will be a cooling in the cloudy mass. For the reasons given above, its potential will be augmented.

"Now if the potential reaches a certain figure, the vesicles, considered separately, could not retain their charge; that is to say, it will escape into the atmosphere in the form of silent discharges. Thus we may calculate that at the ordinary pressure a small sphere of $\frac{6}{10}$ of a millimetre cannot retain electricity at the potential which we obtain with our good laboratory apparatus.

"Because of the smallness of the radii of these vesicles, it may be seen that a cloud cannot retain a charge at a potential surpassing a certain figure.

"Such is the manner in which are produced the phenomena known under the name of heat lightening. As, for different observers, these flashes appear at the horizon, it is logical to think that they are produced at the zenith, and that they are not the reflection of the light-

ning from distant storms. It is a similar phenomenon which transpires when a navigator sees a band of mist continually at the horizon, while the sky above his head is clear. It is only a difference in thickness of the layers traversed by the visual rays."[1]

5. FLOATING MATTER IN THE AIR.

With "floating matter in the air" all scientific readers have been made more or less familiar by the experiments and publications of Pasteur, Bastian, Beale, Budd, and Tyndall. In relation with climate, it consists of vapors and gases, as well as minute particles of various kinds which continually arise from the surface of the earth and water, and commingles with the air, affecting its purity.

The refuse and the remains of animals and plants which undergo the processes of decay or putrefaction under manifold circumstances, and the numerous substances which are burned in the air, all produce chemical compounds, which, being volatile or gaseous, ascend and are diffused in the atmosphere which is made a whirlpool of destruction to all such matter. Some of these substances, like ammonia, are perceptible to the smell, while others are altogether inappreciable by the senses. Living volcanoes belch forth destructive vapors over extensive regions, and thousands of chemical processes and operations, natural and artificial, pour out their volatile exhalations to be caught up by the winds, and to be wafted more or less swiftly and extensively from their sources, mingled with the atmosphere, and destroyed.

In and about uncleanly places and houses, where filthy substances are allowed to be scattered over the surfaces and soaked into the soil, or deposited in pits and cesspools from which an active *ferment* is never absent, various gaseous emanations are constantly arising and commingling with the surrounding air, and not infrequently to a dangerous extent. For although the oxygen of the atmosphere, wherever it can gain access in conjunction with sunlight, is ever active in hastening the transformation of dead organic matter into its elementary constituents, when such matter is amassed, or so placed that the surface only is accessible to the air, oxidation is not only thereby prevented, but the process of putrefaction is also retarded, and the emanations of foul gases which continue as long as the source of supply is kept up, frequently carry with them into the air particles of putrefying substances, often of a very dangerous character, identified with the spread of typhoid fever and other intestinal diseases.

Moreover, wherever organic matter in process of decay exists in conjunction with darkness, moisture, and warmth, the air thereabouts swarms with myriads of living germs, for the most part so small as to be

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[1] M. G. LeGoarant de Tromelin, presented to the French Academy by M. Faye. Translated from *Comptes rendus*.

invisible to the unaided eye, and so light as to be floated by the air, and consequently liable to be drawn into the lungs with every breath. While a large proportion of the germs in such places are doubtless scavengers—devourers of the putrefying matter—and hence always found in greatest abundance in filthy places, it is equally doubtless that a considerable proportion of them are very poisonous and dangerous to human life; these are *disease* germs, believed to be a common cause of infectious diseases. And these, together with the filthy particles upon which they seem to exist, afloat in the air, are not only liable to be taken into the lungs with the breath, but being wafted throughout all such premises, within as well as without the houses, stick to the walls and furniture, settle upon the table and cooking utensils, and into the food and drink, permeate the clothing, and attach to the person. Hence it is that the foul air of such places is not only in itself poisonous, perpetually lessening the vital force of all who inhabit it, predisposing to blood-poisoning, but it creates a nidus for the propagation of disease germs, and becomes a veritable hot-bed for infectious diseases of every sort.

Nearly allied to, if not indeed identical with, disease germs, and perhaps more closely related to the subject of this work, are vegetable spores, most commonly recognized in the form of mould or *fungus*, which, in fruiting, is frequently of a greenish or brown color.

Vegetable mould or fungus, as it exists in the familiar example of mouldy cheese, is the same kind of a plant as mushrooms and toadstools, some of which grow very large. They may be seen, as every observer knows, in almost any meadow during damp, warm weather, amidst masses of refuse in process of decay, around banks of manure, and among the decaying leaves under the trees. A familiar example is the *puff-ball,* because, when dry, if broken, the mass of infinitesimal spores puff out like smoke. Every one of the little spores, which are so fine as to be no larger than the particles of smoke, is a seed. And of some of these plants the spores are so quick that a single one, if planted in a congenial place, will in one night produce a plant as large as the double fist. The number of spores which a single plant of that size will contain is so great that if it were possible to keep one man employed in counting them, it would require the continued occupation of one person day and night three hundred years to count the number.

This example serves as well to illustrate the extreme smallness of disease germs, known to be such, as of fungus spores. Indeed, there is good reason to believe they are only different species of the great division of plants to which they both belong. There are a great many kinds of fungi, and the seeds of one kind or another, and whole plants of numerous other kinds, are always floating in myriads in a dry atmosphere as if in search of congenial places to plant themselves. It is very questionable whether such spores can live for any considerable length of time in an abundance of pure air or pure water in motion; while it is beyond

question that when so exposed both germs and spores are wholly innocuous. But wherever they find congenial resting places, there they take up their abode and flourish until their food supply is exhausted. It may be upon a spoiled apple auspiciously placed; a cheese that has been made out of unwholesome material or that has not been well taken care of; a piece of cake left in a tainted atmosphere; a jar of jam left open under conditions favorable to fermentation; a can of preserved food, fruit or vegetables, fish or meat, left open for convenience; any article of food which has been kept too long, or improperly placed—for example, a pan of milk that has been placed in the same ice-box, closet, or dairy with stale meats and vegetables, or, worse still, as recently observed by the author, in the stow-away for soiled clothing in an institution for the care of children. Or, finally, it may be, on a large scale, filthy streets and yards round our houses, or the accumulation of dirt within them. All of such conditions of things, places, and surroundings are the common feeding ground and fruitful fields of disease germs; unfortunately exempted by no climate, but everywhere dangerous places to live in, and to be shunned by all persons who would not contract infectious diseases themselves, nor be the means of communicating them to other people.

CHAPTER V.

THE STABILITY OF LOCAL CONDITIONS OF CLIMATE.

THE RELATIONS OF LAND AND WATER TO CLIMATE.

PERMANENCY OF GEOLOGICAL AGENCIES—ACTION OF AIR AND WATER ON THE EARTH'S CRUST—DISINTEGRATION OF ROCK—PRODUCTION OF SOIL—RIVERS—OCEAN-CURRENTS—THE GULF STREAM.

THE atmospheric, aqueous, organic, and igneous agencies in operation, modifying the structure of the earth's crust, are probably the same at the present time as they have always been, though they may have acted, as some geologists believe, with a different energy in an earlier period of the earth's development than they now do. However this may have been, it fails to account for the permanent change of climate which evidently took place in the coal period, by which such a revolution of climates took place as to convert those which were tropical into temperate and frigid, and *vice versa*. Such a revolution could only have been brought about by an exchange in the balance between the results effected by the agencies now in progress.

Whether the relations of mass between the ocean and the dry land are the same now as they have always been since the creation of man, scientific data are insufficient to determine. Changes in these would unquestionably affect the distribution of heat, and consequently, proportionate changes in the permanency of climate. That changes in these relations *have* taken place at some period in the progress of the earth's development, the evidences of geology abundantly attest.

The whole of what is now dry land was once under water, and much of it has evidently been a gradual deposition from water. But evidence is wholly wanting of any change in the relations of land and water of such magnitude as to have had any permanent effect upon climate since the modern epoch of the earth's elevation. On the contrary, the constancy and the progress of the agencies now in operation are such as to warrant the conclusion that the alleged changes in climate, of which there has been so much said and written in recent years, are very much exaggerated, if not, indeed, wholly devoid of a substantial basis.

The general effect of the atmosphere on the surface of the earth is everywhere apparent in the disintegration of rocks and the formation

of soils. These changes are effected by the chemical action of oxygen, carbonic acid, and moisture. The evidence of this origin of soils is clearest when the soil is found *in situ*—where there is but little or no slope of the surface, or other cause favorable to its removal. In such cases, it is generally easy to trace every stage of gradation between perfect rock and perfect soil, as may usually be seen in railroad cuttings and in wells, in the gneissic region of the Southern Atlantic States. Near the surface in this region is perfect soil, generally red clay; beneath this that which is of lighter color and coarser, and more distinctly stratified; next below this, shading into barely perceptible gradations of color, it appears as stratified rock, but it crumbles into coarse dust in the hand. This passes by imperceptible gradations into rotten rock, and finally into perfect rock. These are all different stages of gradual disintegration. Wherever perfect soil is found resting on sound rock, the soil has been shifted.

If rocks were solid and impervious to water, the action of the atmosphere upon them would be inconceivably slow; but as they are all more or less broken by fissures, there is an immense exposure of surface, and in cold climates *mechanical* force is added by frost. The influence of the wind in shifting the sands of desert regions, and that which is thrown out by the sea, is also very great.

The depth to which soil will accumulate depends partly upon the nature of the rock, partly upon the inclination of the surface, and partly upon the climate as regards temperature and moisture. But all soils, with the exception of the thin stratum of vegetable mould which forms on certain circumscribed localities, are due to atmospheric agency, though they are sometimes removed as fast as they are formed, and deposited at a distance more or less remote from the parent rock.

Water, in the form of vapor, fogs, or rain, soaked into the surfaces and crevices of the earth, is also a powerful agency in the disintegration of the hardest rocks. Much of the water which falls as rain, however, is never absorbed by the earth, but runs off the surface, forming rills, which, by erosion, produce furrows, rivulets, and gullies. And these, uniting with one another and the larger streamlets, form torrents, ravines, gorges, and cañons; and again, these uniting, form rivers, which sweep down and deposit their freight of soil from the disintegrated rocks by the way, or pour it into the sea. The hydrographical basins of rivers, lakes, or gulfs comprehend the area of land which drains the rainfall into the latter, and upon a knowledge of the surface soil and boundaries of the areas, estimates have been made of the amount of soil removed from them. For example, the area of the Mississippi basin is 1,244,000 square miles. According to the experiments and estimate of Humphrey and Abbot,[1] the discharge of sediment annually from this area amounts to

[1] "Report on Mississippi River."

7,471,411,200 cubic feet, a mass sufficient to cover an area of one square mile 268 feet deep. This spread over the whole basin would cover it to the depth of about $\frac{1}{400}$ of an inch, equal to the thickness of one foot in 4,800 years. This may be regarded as a fair example of the erosive and distributive power of rivers.

The erosive effect of the tides and waves of sea-coasts is more marked. The softer parts are worn away or scooped out into harbors, while the harder parts extend out into the sea, and the progress of these erosions is in some cases so great as to effect important changes in short periods of time. For example, Sullivan's Island, the protecting reef of Charleston harbor, for a few years past has been wearing away at the rate of from ten to fifteen feet annually, insomuch that the Government has been constrained to interpose protecting barriers against the erosion for the preservation of the harbor. Cape May is also losing about nine feet annually.

As a general fact, however, Le Conte states the southern coast of the United States is receiving accessions by the inflow from the sea more rapidly than it is wearing away, while, on the contrary, the New England coast, as proved by its rocky character, is losing much more than it gains. The shores of the great lakes show similar changes.[1]

But far more powerful is the effect of ocean currents. The ocean, like the atmosphere, is in constant motion, not only on its surface, but throughout.

The great and controlling cause of ocean currents, as of the air, is difference of temperature between the equatorial and polar regions.[2]

Water has a greater capacity for heat than the surface of the ground, whence it results that the sea is cooler than the land in summer, and warmer in winter. The sea breezes also add to the influence of the water in preventing the coast-line from being as cold as the country farther inland.

Water becomes less readily heated upon the surface than the ground, because the latter has a specific heat much below that of water. For instance, the quantity of solar heat required to increase the temperature of the earth's surface ten degrees is much less than that which would raise the temperature of a liquid surface the same number of degrees, because the greater capacity of the latter for heat. Moreover, the solar rays penetrate to a much greater depth, and consequently become absorbed to a much greater extent in water than they do in the surface of the earth, insomuch that, at sea, they do not become extinct until they have reached a depth of about a thousand feet. So that the heat arising from the absorption, instead of being concentrated upon the surface of the water, is diffused through a great mass, and is, of course,

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[1] "Elements of Geology," by Joseph Le Conte.

[2] Guyot, "Earth and Man."

less intense in proportion as this mass is larger, but with effects the same as that which heat has upon the atmosphere, and of equal importance—the establishment of marine currents.

The ocean currents are the great rivers of the sea. They move continually through waters comparatively tranquil, but usually distinguishable by a difference in temperature and color. Unlike inland streams, which, in comparison are but threads on the surface of the earth, the ocean currents are scores, ay, even hundreds of miles broad, and their course is over the greater portion of the globe. And they are not only found near the surface, but in many cases at great depths, and moving in different directions.

The cold and heavier waters of the frigid zone tend incessantly to flow into and to displace the warm and lighter waters of the torrid zone. When the currents meet, the cold waters sink below the warm, but anon to return under the influence of heat as surface currents to the polar regions. Hence the two series of currents, the cold from the polar, and the warm from the tropical regions, both, however, deflected from a straight course by the earth's rotation—the polar currents more and more to the west, and the tropical more and more to the east. The polar currents from the two hemispheres unite in the tropical zone, and, aided by the powerful influence of the trade-winds from the great equatorial current, give origin to the Gulf Stream.

The Gulf Stream springs from the accumulated warm waters of the equatorial regions in the Gulf of Mexico. It first becomes appreciable on the west coast of Florida, gently flowing southerly until it reaches the Tortugas, where it bends its course easterly and runs along on Florida Reef till it reaches the confined limits of the strait between Florida on the one side and Cuba and the Bahamas on the other, whence it moves more rapidly, and takes its northward course along the coast of the United States. No longer restrained, it of course widens its bounds and slackens its swiftness, but such is its impetus that it may be distinctly perceived as far north as the Great Bank of Newfoundland, though gradually turning its course to the east from the time it has reached the latitude of New York; thence it crosses the Atlantic basin to the islands of the Azores. Here it divides: the main branch, cooled by contact with the waters from the polar regions, bending its course southward, enters the tropical regions on the coast of Africa, and by the force of the north equatorial current it sweeps back again to the Gulf of Mexico. Thus a great whirlpool is formed in the North Atlantic Ocean, marked by the accumulated and vast amount of Gulf seaweed which bears the name of *mar de Sargasso.*

The northern branch, influenced by the revolution of the earth, continues its slanting course to the British Isles and Norway, and often carries to their shores the evidence of its source—the tropical seeds, seaweed, and drift wood from the West Indies.

The high temperature of the water of the Gulf Stream, as well as its blue color and motion, distinguishes it from all of the other portions of the ocean. It carries congenial warmth all along to the Northern coast of the United States and Canada, and to the west coast of Europe, and gives to the British Isles the temperate climate they enjoy even in the high northern latitude in which they are situated.

The Atlantic Ocean is almost the only outlet of the waters of the north polar toward the equatorial regions, as the Pacific Ocean is that of the south polar waters. Under the influence of the earth's rotation, the polar currents all trend to the west on the American coast. Two main currents, one on each side of Greenland, carry the waters and masses of ice from the Arctic Ocean towards the warmer latitudes—the *Greenland* current along the eastern coast, and the *Labrador* current along the western, from Baffin's Bay. Joining their waters, laden with icebergs, they flow to Newfoundland, where they meet the warm waters on the outskirts of the Gulf Stream, and condensing the moisture of that comparatively mild atmosphere, they produce the everlasting fogs peculiar to that region. Thence, following the coast, between it and the Gulf Stream, the polar current makes itself felt on the northern sea shore as far south as the latitude of New York, where it sinks under the warm waters of the Gulf Stream and pursues its grand circuit.

Other currents though perhaps of less magnitude than the Gulf Stream, are traceable throughout the whole expanse of the waters of the sea.

Such is the process by which the sea serves to distribute heat. The mass of observations collected show that in the northern hemisphere and in the temperate zone the mean temperature of an island situated in the midst of the Atlantic, or at a great distance from the Continent, is higher and the climate more equable than that of a place in the same latitude on the main land—that the winter is warmer and the summer cooler. This has been especially marked in the island of Madeira, and the Bermudas. Hence there is an important difference between the climates of islands or sea-coasts pertaining to continents that abound in gulfs and peninsulas, and the climates of the interior of great and compact masses of dry land.

But besides this chief function of the ocean currents to distribute heat, they serve to distribute over the bottom of the sea the sediments brought down by the rivers. Without this agency, such sediments would be dropped near the shore, none would reach the open sea. There can be little doubt that much of the sediments poured into the Gulf of Mexico from the great basin of the Mississippi and the rivers of the Mexican and Central American coast is deposited on and about the cape and reefs of the coast of Florida and the Bahamas. Great banks far away from shore also owe their origin to the same means. Thus the Banks of Newfoundland are evidently formed by the meeting of the

polar current bearing icebergs loaded with earth, and the warm current of the Gulf Stream. However formed in the first place, when a submarine bank has risen sufficiently near the surface of the water for the waves touching bottom on its border to form breakers, these begin to throw up sand or mud from the bottom until an island is formed, which continues to grow until it becomes inhabited by plants and animals, and finally by man. By the same agency the islands and sandspits have been formed all along our Atlantic sea coast, separating the harbors and sounds from the ocean. These are more or less changeable in their outline from year to year, but in the progress of time the common result is the filling up of tidal inlets and a gradual encroachment of the coast line upon the sea.

The force of the waves, in conjunction with the chief of the organic agencies, is also a powerful means of building up shoals and islands.

CHAPTER VI.

STABILITY OF LOCAL CONDITIONS OF CLIMATE (CONTINUED).

THE RELATIONS OF ORGANIC AGENCIES TO CLIMATE—CORALS AND CORAL ISLANDS—PEAT AND COAL.

The organic agencies comprehended in the structure of the earth's crust are by both animal and plant formation, and those of the former especially are frequently found to exercise important influences over sanitary topography.

Most, if not indeed all, of the inhabited islands of the Pacific Ocean, and of the innumerable islands which gem the seas of all warm climates, and thousands of miles of the inhabited coasts, frequently extending far into the interior of the American continent; all of the marble quarries and lime-stone strata of a former era in the earth's development, and the cumulative coral islands and reefs of the present era have been built up by the *madrepore,* or coral polyp, an animal of the simplest structure, composed of a soft and almost transparent substance, which has the power of multiplying indefinitely by buds and branches. When a large number of madrepores are, by force of currents, planted together, they may be seen at the bottom of clear still waters, where they flourish, shooting up their brilliant stems in groves of every conceivable shade of beauty. In this living group some of the flowers are fully open resembling the petals of the Cypress vine (*Ipmoea quamoclit*), while, others are closed like buds, but constantly changing their appearance from bud to blossom, and from open flower to bud again.

The madrepores always work upwards towards the light, and most vigorously when washed by the beating waves of a rocky bottom. They have never been found, however, at a greater depth than two hundred feet; hence it is to be presumed that all coral beds must have been deposited within this distance from the surface. Their peculiar office seems to be to plant themselves upon submarine elevations, and build them up to the surface of the water. Gradually the accumulating pile rises, and at length, after the lapse of ages, portions of the rocky fabric show themselves above the waves. Here further growth is checked; the polyps cannot live beyond the point where water freely reaches them, from whence they may derive nutriment; hence so soon as the elevation

has reached such a height as to remain dry at low water, they leave off building it higher. Yet they toil on round the edge of the fringing reef. The structure reared becomes a nucleus round which materials are collected. Fragments of seaweed gather round and cling to the rough margin; dead coral and sea shells are strewn over the surface. And the breaking surf at every flood tears up, pulverizes, and commingles the animal and vegetable substances, which, at every ebb of the tide, are exposed to the rays of the burning sun.

The heat of the sun so penetrates the mass when it is dry that it bakes and splits into large fragments. These flakes, so separated, are raised one upon another by the waves at the time of high water, and the always-active surf continues to throw up shells, marine animals, and seaweed between and upon them, to be ground and compacted into the more and more solid mass. Now peering above the waters, drift wood, frequently consisting of the entire trunks of trees which have been carried into the sea by the rivers of distant countries, after long wanderings, finds here at length a resting place. And with these, perchance, come some small animals, such as lizards and insects, as the first inhabitants. Flocks of migrating birds, attracted by the appearance of food, here find a convenient halting place, and bring with them the seeds of plants from their previous abode; anon the seeds take root, spring up and grow, and the strayed land birds take refuge in the bushes.

The older and usually central portions of coral islands, powdered and solidified by the joint action of the surf and the heat of the sun's rays, after a time begin to subside. Meanwhile, the ever active agencies of the living madrepores, many feet below the surface, and the dashing breakers above, are unceasing, and new material is continually being added to the margin. Great sun-baked flakes are tossed up by the breakers of the recurring tides, fencing in the central lagoon, which, by the lapse of centuries, is converted into a refuge, with its fruitful soil around and expanded reefs beyond, invites the explorer, the pioneer, and the invalid to new fields of health, commerce, and fortune.

Such is the process of formation of chalk and limestone in enormous masses, of various kinds, from the beginning, and still in progress, comprehending immense areas of the earth's crust, and in some regions thousands of feet in thickness.

The vegetable accumulations which enter into the structure of the crust of the earth, and exercise influence over climate, are peat-swamps and coal fields.

In undrained places in moist climates, the surface mass of accumulated debris and mud in low places is frequently found to be the mere covering of a black, tough carbonaceous layer, interlaced with roots of many feet in thickness. This substance is known as *peat,* and it commonly rests upon a tremulous, semi-fluid quagmire, sometimes twenty to thirty feet in depth, in which animals in search of food and hunters are

sometimes buried by the breaking through, or by open spaces in the superficial layer.

Some countries are particularly noted for their extensive peat swamps and bogs. One-tenth of the whole surface of Ireland and large areas in Scotland and England are covered with it. There are also extensive swamps in this country. The amount of peat in Massachusetts alone, Dana[1] has estimated to be upwards of 15,000,000,000 of cubic feet, and Le Conte is authority for extensive areas of it in California.[2]

Peat consists of disintegrated and partially transformed vegetable matter, and is composed of variable proportions of the same constituents as the atmosphere, but with carbon and carbonic acid greatly in excess.

Peat swamps are remarkable for their relative exemption from miasmatic diseases, as compared with recent accumulations of vegetable matter in swampy regions before transformation. This exemption is probably due to the presence and antiseptic properties of humic acid and of hydrocarbons analogous to bitumen, which are found only when vegetable matter is decomposed in contact with excess of water.

The conditions commonly considered the most promotive of the formation of peat are cold and moisture; and of these the former is thought to be the most important, as, without cold, it is assumed vegetable matter would be destroyed by decay, and in proof of this it is stated that peat-swamps are more numerous in cold than in warm climates. But this is doubtful. Moisture is unquestionably an essential condition under all circumstances, and wherever this is found to have obtained in excess, with an abundance of vegetable matter, peat-bogs are also found. The great Dismal Swamp in Virginia and North Carolina is a prominent example, and the writer has observed the same condition in other and still warmer climates. It is probable that the peat of such regions is an additional element to their salubrity, more particularly noticed in the chapter on Forests.

Coal formations, which appear to be but another step in the progress of the transformation of organic into inorganic matter, everywhere bear evidence of their relation to climates.

The climate of the coal period over regions of the earth's surface which are now great coal fields was undoubtedly characterized by much greater warmth, humidity, and uniformity, and a more highly carbonated condition of the atmosphere than that which now obtains. But the evidence which the coal formation bears to the probability that the greater part, if not the whole of it, as it now appears, was effected under climatic conditions unfavorable, and probably previous, to the existence of man upon the earth, and the extreme slowness by which this transformation takes place, is such as to divest it of any present significance in relation with climate.

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[1] "Manual of Geology."

[2] Loc. cit.

CHAPTER VII.

HEAT.

LAWS OF HEAT—THE ZONES—HOW THE TEMPERATURE OF THE EARTH'S SURFACE IS MAINTAINED—DIFFERENT CONDITIONS OF HEAT—ANOMALIES OF EXTREME HEAT IN THE EASTERN STATES, AND ITS DANGERS—RELATIONS OF HEAT TO ALTITUDE.

HEAT it the fundamental power of climate. The atmosphere is the life of the world, but if the atmosphere were not the carrier of heat there would be no life.

It is heat which sets the air in motion, governs the course of the winds, moves the currents of the ocean, supplies the atmosphere with moisture, distributes the rains, and distils the dews. Hence a knowledge of the laws which govern heat are of primary importance in the study of climate.

Experiments show that nearly all bodies are subject to *expansion,* or increase in volume by the application of heat, and recover their original size when reduced to the initial temperature. Thus if the temperature of an iron bar be raised 5°, and thereby increased in length one inch, by elevating the temperature to 10° it will have increased two inches. Or if a ball of iron be made of such a size as to pass through an aperture at a temperate warmth, it will not fall through when heated. Liquids are in like manner amenable to the law of expansion. If a glass tube be inserted through a cork into a flask filled with water, and heat applied, the water will rise in the tube, and the higher as it becomes warmer. It is in accordance with the same law that the thermometer was constructed, and operates by the expansion of mercury, or, rather, by dilating in equal amounts for equal increments of heat.

But water is an extraordinary exception to the law of expansion by heat. It contracts till cooled down to the temperature of 40° F., after which it expands. It is in consequence of this peculiarity that ice always floats. This effect of heat on water is illustrated by another, and a very curious consequence. When a pool or a well of melted ice happens to be formed on the upper surface of a mass of ice, as not infrequently happens in the glaciers of cold regions, the well quickly increases in depth until it entirely penetrates the ice to the earth beneath. Supposing the water at the surface when the pool or well first forms to be

about or but little above the freezing point of 32°, as it becomes heated by the air and sun's rays, instead of being thereby expanded (as it would if it conformed to the law of expansion), and rendered specifically lighter and detained at the surface, as it more nearly approaches the temperature of 40° it becomes heavier, and therefore sinks down to the bottom; but there, by melting some of the ice, and consequently becoming cooled, it is again made lighter, and, rising again to the surface, gives place to another descending portion, which has, from exposure, acquired the same properties, and so on; the circulation and digging cease only when the water has bored its way quite through the ice to the surface of the ground.

The manner in which heat is communicated through liquids, is by *convection.* When applied to the lowest part of the mass, for example, to the bottom of a tube containing water, the particles heated expand, and becoming lighter, ascend, while the colder particles from above descend and supply their place. The process may be clearly shown by throwing into the tube, while the water is boiling, some insoluble powder whose specific gravity is the same as that of the water, when a series of upward and downward currents will be exhibited, which will continue as long as the boiling.

Gases become heated in the same way as liquids, though the currents have more of a wavy or cloudy form, unless, as is seldom the case, the air is perfectly still, when smoke is seen to ascend vertically, and fogs and vapors rise in the same manner.

Gases and vapors expand by heat; and air which is a gaseous compound, conforms to the law.

The results of scientific experiments show that the ratio of expansion of a volume of air in passing from the freezing to the boiling point of water is $\frac{365.5}{1000}$; that is to say, a quantity of air equal in volume to 1,000 cubic inches at 32° F. will expand to 1365.5 cubic inches at 212°, or by an increase of 180° of heat. Hence, as it has been proved that the expansion is the same for each additional degree of heat, the expansion will be equal to 0.002036, or $\frac{1}{491.2}$ for each degree :—

Four hundred and ninety-one cubic feet of air at a temperature of 32° will become 492 at 33°
493 at 34°
490 at 31°
489 at 30°
488 at 29°, etc.

Solid bodies lose or acquire heat by *conduction.* The particles nearest the source acquire heat and transmit it to those in contact with them, and these to the next, and so on till the whole mass has attained the heat of the surrounding medium. If the temperature of this medium, suppose the air, be reduced, the surface of the heated body radiates forth its heat from the interior till equilibrium is restored.

According to the greater or less rapidity with which heat is diffused throughout a substance, so it is said to be a good or a bad conductor of heat. Metals are good conductors; gases, liquids, and earthy matters, scarcely conduct at all. The loss of heat by radiation greatly depends upon the nature of the surface: smooth or polished surfaces radiate much more slowly than rough surfaces.

Glass and wood are bad conductors of heat. For illustration, a piece of wood may be held in the hand and burned until within a short distance from the flame, or a glass rod held by the fingers within an inch from the flame of a blow pipe, without inconvenience, whereas the end of an iron wire, which is a good conductor, held in the same flame and heated to redness, will be heated and rendered intolerable for a foot or more from the flame.

Air is a bad conductor, and hence the utility of double windows in cold climates, which include a layer of air between that prevents the radiation of heat from the rooms into the colder atmosphere without.

Ice is a bad conductor, and snow a still worse. A surface of ice prevents the cooling of water underneath; and snow prevents the ground from freezing, and protects the delicate roots of plants from the effects of severe cold.

The barks of trees are bad conductors, and exhibit a structure of porous material, with pores filled with air; which finds its imitation in the cover of the boilers of steam engines with wood and felt. And for the same reason, ice is wrapped in flannel because the flannel is a bad conductor, and prevents the external heat from reaching it.

The crust of the earth is almost wholly composed of bad conductors of heat. Hence, although the interior of the earth is well known to be of a much higher temperature than the superficial layers, no heat is communicated to the surface from the interior. And for the same reason, the sun's rays, upon which the surface of the earth wholly depends for its warmth, never penetrate to any considerable depth—the temperature of mines and wells, even a few feet deep, continue about the same for summer and winter.

Liquids are also bad conductors. If a tube be filled with water, and held aslant over the flame of a spirit-lamp, the water may be made to boil from the top, while a piece of ice may be retained at the bottom.

Although the earth is a warm body, which at the beginning was probably incandescent, it has so cooled down at the surface by the lapse of ages as to retain scarcely a trace of its original temperature. Nevertheless, we know that the temperature of the earth increases as we descend into the interior at the rate of about 1° to every 112 feet, and that the internal heat must be very great underneath volcanoes. Nine thousand feet of depth, or about one mile and seven-tenths gives the temperature of boiling water; at the depth of thirty miles, at the same ratio, the heat is sufficiently intense to melt all the rocks and metals

contained in the earth's crust, and to account for the torrents of molten fiery lava belched from the craters of raging volcanoes. It is to this internal heat of the earth that hot springs, and the warm water of deep artesian wells are due. But all the heat available for the purpose of organic life is unquestionably due to the influence of the rays of the sun.

Though the sun pours its life-giving rays in a uniform and uninterrupted stream upon the earth's surface, the spherical form of the earth and its movements of daily rotation on its axis and annual revolution around the sun, establish permanent differences of temperature, in every latitude between the poles and the equator, and periodical differences upon the seasons, and upon the diurnal rotation for day and night.

The division of climate into zones is based upon the permanent differences in the power of the sun's rays on the earth's surface.

Two imaginary parallel lines to the equator upon the surface of the globe, at the distance of 23° 28′ in each hemisphere, designate two circles between which the sun passes across the zenith at certain epochs of the year: these are the *tropics*. That of the northern hemisphere is known as the Tropic of *Cancer*, because during the summer solstice the sun passes at its zenith and is in the zodiacal sign of Cancer. That of the southern hemisphere is known as the Tropic of *Capricorn*, because the sun passes at its zenith during the winter solstice in the zodiacal sign of Capricorn. The space included between these two circles comprises that portion of the earth's surface over which the sun rises to its greatest and most vertical altitude, and sheds forth its rays with the greatest degree of intensity, is termed the *torrid* zone.

Two other circles, distant respectively 66° 32′ from the equator, or 23° 28′ from the poles, in each hemisphere, mark the lines below which the sun may remain for several days together, and above which it attains its least altitudes: these are the *polar* circles, which include the *frigid* zones. During one-half of the year, the sun rises above the polar circles to the height of 23° 28′, and during the other half descends below them to the same amount.

The *temperate* zone is that portion of the earth's surface which is between the torrid and frigid zones.

The areas in square miles of the respective zones is:—

North tropical zone, . .	39,109,628	Warm region,
South " " . . .	39,109,628	78,219,256.
North polar " . . .	8,229,748	Cold region,
South " " . . .	8,229,748	16,459,946,
North temperate zones, . .	51,110,763	Temperate region,
South " " . .	51,110,763	102,221,526,

It thus appears that the regions most favorable to mankind, the temperate regions, are far the most extensive; and next, the warm regions;

while the frigid zones, unsuited for human progress, extend over a comparatively inconsiderable portion of the earth's surface.

In the regions of, and near the equator, in both hemispheres, the various causes which influence the action of the sun's heat vary but little throughout the year. The day has about the same length all the year round; the meridian height of the sun undergoes but little variation, and the four seasons differ very little in regard to temperature, the one from the other. For an entirely different cause, in the regions where the length of the day varies very much in the course of the year, or where the meridian height of the sun at one solstice is very different from that of the other, the seasons are very dissimilar both to the north and south of the equator.

The angle at which the solar rays reach the surface of the earth are the chief cause of the succession of climates from the equator to the poles, and if the earth's surface were perfectly regular in shape and consistence, instead of being divided into land and water, forests and arid plains, table-lands, mountains and valleys, etc., the diminution of temperature would be progressive and regular. These irregularities of the surface give rise to the various differences of climates in the same latitudes, and, under the influence of heat, tend to maintain a perpetual circulation of the atmosphere, and the equalization of temperature. Thus the trade-winds, which establish a double current between the equator and the poles, temper the cold of the high latitudes over which they pass, and the heat of the tropical regions where they arise, heating the former and cooling the latter.

Gases and vapors, as before shown, possess the property of absorbing heat rays, and consequently the atmosphere absorbs a portion of the rays transmitted by the sun. But the power of absorption by different gaseous substances greatly differs. Professor Tyndall, after many elaborated experiments on the absorptive power of different gases, concludes that on an average day the water present in the air absorbs about sixty times as much heat as the air itself; and Professor P. M. Garibaldi has shown that the absorptive power of heat, under a barometric pressure of 29.92, by different gases, stands in the proportion of

Atmospheric air (oxygen and nitrogen)	1
Carbonic acid	92
Ammonia	546
Vapor of water	7,937

Hence it appears that the actual amount of heat of the air derived from the sun's rays in their transit, compared with that which is radiated from the earth's surface, is very small.

The lower portions of the air are heated by radiation from the earth's surface, communicated by convection, and to this source may be traced the greatest portion of the heat it exhibits. The greater portion of the

sun's rays which are received by the earth are deprived of their power of being reflected back again into space by the interposing moisture, and its great capacity for heat.

But the amount of *specific* or absolute heat which different substances contain greatly differs, although their temperature, as indicated by the thermometer, may appear to be the same. If, for example, two glass tubes, in every way alike, one containing mercury and the other water, be subjected to the same degree of heat by plunging them into a vessel of hot water, the mercury will attain the degree of the surrounding medium in half the time the water will take; and on removing the tubes and allowing them to cool, the mercury will take only half the time to recover the initial temperature as the water: this effect arises from the difference in the absorbing power of the two substances, mercury absorbing less heat than the water in being raised to the same temperature; or, as usually expressed, water compared with mercury has twice the *capacity* for heat.

In comparing the capacity for heat of different substances, it is usual to take equal weights of each rather than equal volumes.

A pound of distilled water takes a certain amount of heat to raise it a certain number of degrees; to this standard other substances are reduced: if a pound of mercury requires .033 of the same degree of heat to attain the same temperature, the specific heat of water is to that of mercury as 1,000 to 33. According to the same standard, the specific heat of various substances has been ascertained to be as follows:

Substances.	Specific heat of equal weights.
Water	1,000
Ice	513
Iron	113.8
Copper	95.15
Zinc	95.55
Glass	198
Mercury	33.32
Lead	31.4
Air	3,705

The great capacity of air for heat has already been shown.

The aqueous vapor suspended in the atmosphere, though it may extend only a few feet from the surface of the earth, constitutes a moist stratum which as effectually retards the nocturnal process of cooling as the whole atmosphere. Indeed, the most striking facts in connection with the temperature of the atmosphere are the absorption of heat which accompanies the transformation of water into vapor, and the part played by the vapor in maintaining the temperature of the earth's surface. This is *latent* heat. It is so named because it does not affect the sense of touch or the thermometer; it may be thus illustrated:—

If a vessel be filled with ice in a melting state and subjected to the application of heat, a thermometer placed in it will not show a temperature above 32° F. till the whole of the ice is melted: not till then will the temperature of the water begin to rise. The heat thus absorbed by the ice in passing from a solid to a liquid state has therefore become latent. It is the effect of the same property—the absorption of heat by liquefaction—which chills the air during a thaw: the ice and snow absorb heat from the surrounding air during the process of melting.

Evaporation from the surface of water proceeds at all temperatures, and goes on gradually and insensibly: the particles of water rise in the air, and are mixed with it, and, unless they exist in large amount, are invisible. Whenever evaporation takes place, heat is absorbed from some contiguous substance to supply the amount which becomes latent in the conversion of the liquid into vapor; hence evaporation is always a cooling process. From the same cause, ether, which evaporates rapidly at a low temperature, applied to the surface of the skin produces the sensation of cold; and the evaporation of water from the surface of a porous jar cools its contents; but in this case the water of the vessel exudes through the pores and forms on the outside of the vessel like dew, and this is rapidly taken up by the surrounding air, just as the moisture is taken up, as so beneficially experienced, in hot climates.

The insensible evaporation of water and the diffusion of its vapor in the atmosphere may be proved by exposing a shallow vessel out of doors filled with water: in a few days of dry weather, it will be found emptied of its contents. If the surface of the vessel be of a given area, say one square foot, and the water be weighed from time to time, the loss of weight will give the rate of evaporation for the temperature and locality for one square foot of the surface.

The process of evaporation is always going on on a large scale over the surface of the ocean, seas, lakes, rivers, and moist surfaces everywhere.

The absorption of the heat by the moisture evolved in the process of evaporation has the effect of cooling the surfaces from which it is taken, but the temperature of the vapor is not thereby sensibly increased, it is latent; but at such a degree of temperature as to sustain the vapor. The heat which is thus absorbed is destined to be transported to the most distant latitudes, and to establish and maintain in the atmosphere an equality of temperature which would not otherwise be produced; it is restored to the earth again in its entirety when it returns to the liquid state as rain. The quantity of heat which thus passes from the equatorial to the polar regions is beyond conception.

The smaller the amount of moisture which the atmosphere contains, the more easily it is traversed by heat. At an altitude of 4,000 feet and upwards, the increase of heat in the sun's rays relative to the temperature of the surrounding air becomes a marked feature, insomuch that, at an

altitude of from 6,000 to 10,000 feet above the level of the sea, the thermometer exposed to the rays of the sun usually registers about one-third higher than when in the shade.

The difference between the indications of the thermometer in the shade and in the sun augments with elevation, on the authority of Dr. Charles Denison, "*one degree greater difference between the temperature in the sun and shade for each rise of 235 feet.*"[1]

But the general result of altitude shows that the temperature decreases about 1° Fahrenheit for every 345 feet elevation.

Humbolt observed that the decrease of temperature by altitude varies in different countries, as follows:

"The decrease in a southern atmosphere was 1° F. to 344 feet in the mountains, and 440 feet upon the table-lands. A series of places in Southern India gave 320 feet; in the north of Hindoostan, on the other hand, the decrease was 1° in 410, about the same as upon the table-lands of America. Everywhere analogous differences of level are remarked; in Western Siberia, 1° in 450 feet is the result arrived at, and this number is converted into 440, if the comparison includes the elevated regions of Northern India. In the United States, the decrease is 1° to every 400 feet. The configuration of the country seems to be the most important element in the calculation. If there is a gentle rise in the ground, or if the country is made up of successive gradients, the decrease in the temperature is much more gradual than upon the sides of steep mountains. In the first case, 1° may be taken to represent a difference in level of 420 feet; in the second, of 350 only."[2]

Although what is above stated in regard to the decrease of temperature on the increase of altitude is a general law, in hilly regions and a general prevalence of calm weather the law is reversed; the cold air, by reason of its greater density, descending into the valleys, and the warmer rising to the top of the hills. If there be wind enough, however, to create a disturbance and intermixture of the higher and lower strata, this exception to the general law does not occur. These facts are familiar to observant people in hilly regions generally, but they have not been sufficiently taken account of in meteorological observations to render them popular for the protection of health. The damp and chilly valleys, with their attendant ills, are more frequently chosen as building places than the dryer, warmer, and healthier hills.

That the atmosphere under the influence of heat is in a perpetual state of circulation; that the sea which covers three-fourths of the earth's surface is distributing temperature to every shore; that there are general winds which periodically traverse the different regions of the globe from the equator to the poles, which temper at once the cold

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[1] "Rocky Mountain Health Resorts," etc., p. 70.

[2] "Aspects of Nature."

high latitudes in their course and the heat of the tropical regions, warming the former and cooling the latter, are all so many evidences of the insignificance of mere latitude as an indication of temperature. Nowhere in the world does this insignificance of latitude appear more marked than in the eastern portion of the United States, nor is it anywhere more deserving of attention with relation to the public health.

Reasoning upon latitude as an index of the general course of climatological differentiation, the natural inference would be that the extremely high temperature which occasionally occurs in this region is due to the transfer of the heated atmosphere from a more southern latitude. But the facts are quite the contrary—the temperature in that direction at such times is frequently lower. It is not at all uncommon when the temperature reaches the nineties in Baltimore, Philadelphia, New York, and Boston, that of Charleston and Savannah will be from three to five degrees lower; and in the interior of the Carolinas and Georgia, and along the Gulf coast it is sometimes, at corresponding periods, still lower.

And no less striking is the opposite extreme—the Arctic severity of some winter days or weeks, when the temperature is several, and sometimes many, degrees higher than it is several parallels of latitude further north. The reader who carefully studies the records and charts in subsequent chapters will not fail to observe that there is a general movement of the climatic changes in the United States from west to east, rather than from the south to the north, or in the opposite direction. Yet these excesses of heat and cold rarely or never occur in the regular line of the westerly current south of the 42d parallel. During the summer, the Lake district and British America north of the 42d parallel are warmed by the westerly winds, but south of the 38th parallel they seem to exercise no regular influence.

How far this difference is due to floating masses of ice on the northern sea-coast at one season and the warmth of the Gulf Stream uninfluenced by this condition at another, is mere matter of conjecture. The fact, however, is of very great importance in its sanitary bearings, especially during the period of high temperature, as possibly accounting for the rise and spread of epidemic diseases, particulary of yellow fever, in extraordinary localities equalized for the time being with the usual habitat of that disease, by the intensifying effect of the high temperature on local conditions; and moreover, for the same reason, a special source of danger in regard to the rise and spread of epidemic diseases of various kinds in places where filth is tolerated.

Considering the properties of the atmosphere, the relations of land and water, and the variable surface of the earth from the ocean level to the greatest altitudes, it is clear that no true estimate of the temperature of the atmosphere is possible, except from actual measurement.

Appreciating the necessity of something more definite and tangible than the zones and mere thermometrical records at different places,

Humbolt marked upon a map all the points at which reliable thermometrical observations had been made, noted the degrees recorded, and then traced lines passing respectively through all the places where the mean temperature was the same. These he termed *isothermal* lines.

During the sixty years which have since elapsed, similar records have been multiplied and elaborated so as to include barometrical pressure, the direction and force of the winds, humidity of the atmosphere, precipitation, and other observations—as shown in the following Chapters.

CHAPTER VIII.

THE WINDS.

HOW PRODUCED—TRADE WINDS—INFLUENCE OF THE SEASONS—TOPOGRAPHICAL INFLUENCES—RELATION TO CERTAIN DISEASES.

When the air is heated, its weight is diminished and it ascends, whereas that which is colder and heavier flows in to supply its place. When, for example, a cloud passes over the sun, the air that is situated in the line of its passage between the cloud and the earth is, by the interception of the sun's rays, rendered colder; this cooled air undergoes condensation, and by reason of this, it flows in the direction of the cloud. The hotter and more expanded air next to it rushes in to supply its place and a current is established—this is wind.

The great atmospheric currents at the equator are set up in the same manner, and in virtue of the same law, the restoration of an equilibrium.

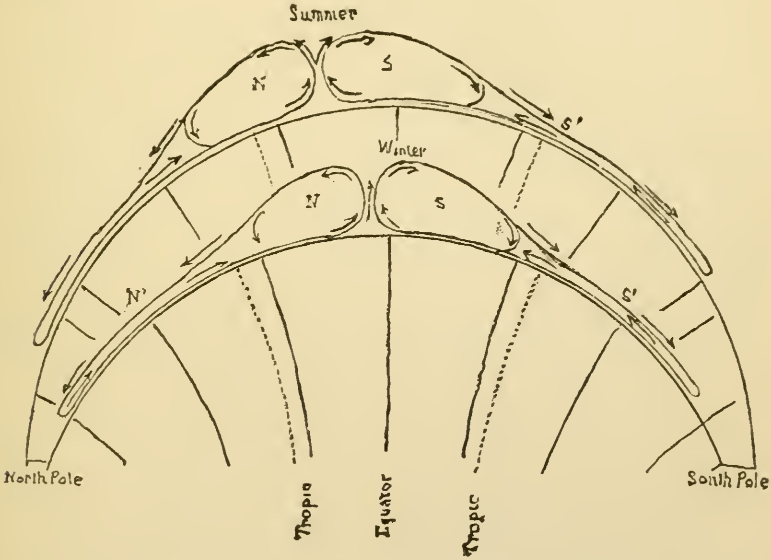
The heated air of the tropics ascends into the higher regions, and after reaching a great altitude, divides and flows towards the respective polar regions; meanwhile the air which is near the surface of the sea and land on both sides of the equator flows towards it to supply the place of the ascending current. Thus we have a double atmospheric current established over the entire globe; that which moves near the surface and falls under our observation constitutes the *trade winds*. The ascending and divergent currents are termed the anti-trade winds.

While the trade winds are observed to proceed with great regularity in and near the tropics, more or less variable on account of the relations of land and water, the greater the distance therefrom the more diffuse they become; and finally in the temperate and more northern latitudes they are influenced to such a degree by topographical conditions as, under some circumstances, to appear to be superseded.

The general circulation of the atmosphere, it seems almost unnecessary to remark, is influenced by the seasons. At the end of the summer season, the polar regions have for several months had days without nights, and the temperature there has become perceptibly milder and the air consequently more rarefied. But to days without nights succeed nights without days, accompanied by increasing cold and an increasing draught upon warmer latitudes for a fresh supply to fill the vacancy

caused by condensation. The anti-trade winds flow with augmented volume and strength to supply the deficiency, and the cold surface-currents flow with a correspondingly increased impetuosity in the opposite direction—with proportionate perturbations characteristic of winter.

As the sun makes its way back again, and the night of the polar regions is changed into day, the atmosphere again expands; the equatorial current slackens and dissipates its strength over lower latitudes, and summer returns. Each of these changes in the respective hemispheres is the reverse of the other; there is therefore a complete transposition of the atmosphere with every change of the seasons from the northern into the southern hemisphere, and *vice versa.* The movement of the atmosphere in these relatiens is well illustrated in the following diagram from Flammarion:



SECTION OF THE ATMOSPHERE SHOWING ITS GENERAL CIRCULATION.

"Two leading circumstances cause the aërial currents to travel out of the limits comprised in the above circuits, and give rise to two secondary circuits (N′ and S′); these are, the rotation of the earth upon its axis around the sun, and the division of land and water over the globe.

"The earth turns upon its axis in the direction of west to east. In virtue of this rotation, every point of it completes a revolution in the same period of twenty-four hours; but in this interval of time all parts do not traverse the same distance or move at the same rate of speed. At the equator the speed is about 416 leagues an hour; in the latitude of Paris it is 273; at degree 56 it is 231—as at Edinburgh, for instance; at the poles it is nothing.

"The air which seems to us to be in repose at Paris is, in reality moving there at the rate of 273 leagues per hour. Let us imagine this air transported to latitude 56° without any change in its velocity; it will continue to travel 273 leagues per hour. As each point in latitude 56° travels 231 leagues per hour, the air will gain upon the ground in an easterly direction, at the rate of 42 leagues an hour! which would constitute a hurricane. The reverse would be the case if a mass of air, relatively still, in parallel 56°, were suddenly transported into parallel 492. This air would appear to us to be travelling from east to west at the rate of 42 leagues per hour.

"In reality these passages of air from one parallel to another always take place gradually, and, during their transition, resisting causes of various kinds tend to equalize their velocity. The lessened differences none the less continue in operation, and, as the size of the parallels of latitude diminishes the more rapidly on approaching the poles, the effects pointed out above become more and more pronounced as they occur in high latitudes. Many tempests are derived from this cause."[1]

While this explanation of the philosophy of the winds in both their origin and their general course is believed to be the correct one, some writers prefer to account for the winds, of the temperate latitudes particularly, by the uneqal distribution or heat and of land surface. In regard to such views, and to the evidences of a general circulation, Blodget observes:

"The greatest fact of evidence, as well as the greatest practical point in relation to the subject involved here is *the constancy of westerly winds in the middle latitudes.* At the fortieth parallel as an average position, and on the isothermal line of 50° for the mean of the year as a central line, the evidences of this prevalence and constancy are overwhelming; and if, in the interior of the continents, there is a period or locality where they are interrupted, it is but an exception to a rule. In truth it appears that such interruption only occurs in the months of extreme heat or extreme cold, and then it is not known that the exception embraces more than the immediate surface air, leaving the upper strata, as is so often evident in the United States, to pursue a regular course from some westerly point.

"In the Atlantic Ocean, where no disturbing land areas exist, this west wind is strongest and most constant, so much so that at certain seasons sailing vessels cannot make the passage in a line from the British islands to New York. The isothermal line which should control the precise direction of these winds, if the supposed cause be the true one, here runs northeasterly, and the prevalent winds have the same direction. Their resultant would be quite accurately along that line, and their strength and violence can be accounted for on no other

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[1] Op. cit., p. 272.

hypothesis than that of a general movement of the atmosphere eastward. The simple facts for the Atlantic Ocean alone settle the question that other influences than those relating to land and sea simply, or than those which generate a sea-breeze on a narrow coast and a monsoon on the border of a great continent, enter into the account as causes. . . .

"The resultant at all observed stations, whether estimated numerically or observed with accurate instruments of registry, is uniformly from some westerly point, and the average of positions from the 38th to the 45th parallel in the United States is from due west. Prof. Coffin has accumulated these observations at great labor, and has deduced their resultant in several forms, all concurring to show that a strong and uniform westerly movement belongs to all the middle latitudes of the temperate zone, and one stronger indeed at the east coast of the United States than in the interior. If the cause of winds here lay wholly in the local contrasts of cool and heated surfaces, the reverse current, or one from the east should prevail, for the summer at least.

"So far as this belt of westerly winds is concerned, or, more properly, of atmospheric movement from the west, which may be felt as such winds or not according to local circumstances, even where the clouds of a moderately high stratum are steadily from the west, it does not appear that any evidence could be stronger than that which has become an indisputable part of the general knowledge. It is cumulative on every hand, and it would weaken rather than confirm it to cite partial statistics. With the known direction that all storms, either general or local, take in the United States above the 32th parallel, it is superfluous to seek other evidence that the atmospheric movement is from the west in the general level of cloud formation. The showers and cumulous clouds of summer always have this movement, and with these, as with the general storms of winter, it is of no consequence what the course of the winds at the surface may be. Below the 35th parallel, and on the Gulf coast only, do the showers of summer take a different movement, showing that the stratum occupied by the cumulus of average height does not there move from the west, but from the east or southeast, an inflection of the trade wind mingling with a local coast wind. . . .

"There is next a proof that such a circulation exists derived from the quantity of rain deposited in the temperate latitudes, and particularly in portions of them which are obviously beyond the reach of direct sea air. The rains of the Eastern United States fall mainly from the upper or westerly cloud in all cases. It is seen to be impossible that it should be otherwise, when the phenomena attending it are considered. In illustration the common incidents may be cited: A storm may begin at Buffalo, with wind and clouds from northeast or southeast, long before it is felt at Albany, and though the sky at the moment is so much obscured as to render it impassible to an upper cloud, yet a careful observer would have seen such an upper cloud *preceding* the lower in

formation, and from which the water must necessarily fall, since the lower clouds are but its incident and attendant. The storm may be exhausted at Buffalo before it is known at Albany or Boston, at which places the sky may be clear and the wind continue westerly. It is impossible that such a storm, subsequently being transferred to Boston, should receive its principal supply of water from any other source than the mass of air moving from the west. The prevalent westerly winds must therefore be largely charged with vapor, and must exhibit a nearly constant precipitation either as clouds or rain.

"In confirmation of this view, we find all this belt of westerly winds to be a belt of *constant*, or *equally distributed rains*. Though changing place as the seasons change, the region of monsoons rarely or never comes within its limit, and there is no known district of periodical rains within it except a very limited line on the Pacific coast of the United States, and in this the season of interruption is very short, and the rains are extended into spring and autumn. The west winds of the summer at San Francisco are an exception and anomaly, falling in the latitude of calms for summer, because of the extreme contrasts of the temperature of the sea and the interior.

"The fact that this belt is one of constant precipitation is strong if not decisive proof that it has a supply of moisture from some exterior source. In the wide belt of irregular winds and calms, and of trade winds which can have no such supply, the most extreme contrast and irregularities exist, and it is everywhere characterized by *periodical rains*. Having no uniform supply analogous to that carried to the temperate climates by the returning equatorial current, it is only in the alternation of seasons and of positions that precipitation occurs.

"Accepting this as the theoretical solution of the winds, or atmospheric movements rather, of the temperate latitudes, the analysis of the observed results is easy. With these regular movements which find a general expression in the winds, there are to be found many irregularities and many instances of abnormal movements, monsoons, etc., as parts of the general effect produced by the positions of continents and their relation to the distribution of heat and to the seas." [1]

Prof. Guyot remarks that:

"If the tropical zone is that of constant and periodical winds, the temperate regions are those of *variable* winds, for all the year round they blow alternately without apparent rule from every quarter of the horizon. Two winds, however, in our hemisphere, the N. E. and the S. W., are more steady, and so commonly prevailing that they may be called the normal winds of the temperate latitudes. The N. E., cold and dry, is the polar wind deflected by the earth's rotation; the S. W., warm and moist, is the returning upper equatorial current, which grad-

[1] "Climatology of the United States," by Lorin Blodget, pp. 357–360.

ually descends and reaches the surface about the 30th degree of latitude, blowing from the S. W. The polar or equatorial winds, flowing side by side, or one above the other, but in contrary conditions, encounter each other, each constantly struggling for the mastery. Their fierce battles are our never-ceasing storms; our latitudes their battle field. They control the weather. The S. W. equatorial brings us heat, cloudiness, and rain; the polar winds, clear sky, dry, cold, bracing air, and sunshine. The science of the winds is the science of the weather." [1]

Moreover: "It is fully established that there are on the surface of the earth five systems of winds, which roughly correspond with the zones of climate and temperature, and that the boundaries of these systems vary in latitude with the change in the declination of the sun. In the torrid zone the resultant of the wind is from an easterly direction toward a variable middle line, giving rise to what are called the trade winds. In the temperate zone, the average direction of the wind is from the west; and again in the arctic and antarctic regions, the resultant is from an easterly direction; and, furthermore, the limits of these systems of winds are connected with regions of high or low barometer. Thus, in the equatorial regions, the barometer above the middle line is below the average height of thirty inches, while along the northern and southern limit of this region there is a belt of high barometer, and, again, on the northern and southern limit of the winds of the temperate zone there is a belt of low barometer. The direction of the wind in these several regions and the belt of high and low barometer are referred to the unequal action of the heat of the sun in rarefying the air at the equator, causing an in-drawing current at the surface of the earth, which takes a westerly direction on account of the revolution of the earth on its axis, and a current towards each pole, which from the same reason has a direction from the west. The equatorial current, cooling above, descends by its superior weight, at the northern limit of the trade winds, producing the belt of high barometer, from which, in opposite directions, two currents move, one returning towards the equator, forming the trade wind; and the other, proceeding northward, having a westerly component by the revolution of the earth, tends to move in a direction from the west. It is probable, however, that a portion of the upper wind from the equator flows entirely to the pole, and there, by cooling, descends, consequently having a northeasterly direction. The point of union of these two currents produces an upward motion, again giving rise to the northern belt of the lower barometer." [2]

Dr. Benjamin Ward Richardson remarks—

"That certain winds are provocative of certain symptoms of disease, and that they intensify certain symptoms in those who are suffering

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[1] "Winds." Johnson's Universal Cyclopædia.

[2] Smithsonian Report, 1875, p. 23.

from disease, is a part of universal, as well as medical, knowledge. Thus the southwest wind is known to be unfavorable to acute inflammatory conditions; the north and northeast winds to neuralgic and rheumatic conditions; while the drying, cutting depressing east wind is fatal to those in whom the store of vital energy is very low. But here we are wanting in the precise part played by the winds as causes of disease. It is not obvious that the winds determine the origin of any disease, and whether they intensify any by a special action of their own, independently of heat, cold, moisture, electrical tension, and other such active influences, remains to be discovered. . . .

"On the general subject of winds and geographical distribution of disease, we are much indebted to the researches of Mr. Alfred Haviland, who has devoted many years of splendid labor to this investigation. His inquiries extend particularly to four classes of disease; namely, rheumatism—its concomitants; heart disease and dropsy; cancer in females; and pulmonary phthisis.

"Respecting heart disease and dropsy, which Mr. Haviland considers are almost entirely dependent on rheumatism, he infers that:—wherever the sea air has uninterrupted access, as over a flat country, up broad vales or valleys, and elevated country, we find a low mortality from heart disease and dropsy. And that, on the contrary, in places where the tidal wave has no access, where the rivers run at right angles to its course, or to that of the prevailing winds, there is the highest mortality from the same causes of death.

"Respecting cancer, Mr. Haviland infers, 1. That the hardest and most elevated rocks, or the most absorbent, like the oolite and chalk, are the sites where the least mortality from cancer is found.

"2. That along the river courses which flood their banks, seasonally, are to be found the districts in which the highest mortality from cancer takes place.

"3. That wherever, from the nature of the rocks forming the watersheds, the floods are much discolored by alluvium, and where from the flatness of the country the floods are retained and are not easily drained off, there we find the greatest mortality from cancer among females.

"Respecting pulmonary phthisis or consumption, Mr. Haviland infers that districts with sheltered positions yield a low rate of mortality from the disease. That districts with a general aspect favorable to the malign influence or the east wind yield a high death-rate. That damp clay soil is coincident with high mortality; and that the elevated ridges of non-ferruginous and infertile carboniferous limestone and coral formation, and elevated, hard, unfertile, and non-ferruginous silurian formations, form districts of extensive high mortality from the disease. That elevated parts exposed to westerly, northwesterly, easterly, and southeasterly winds are characterized by high mortality. That a sheltered

position, a warm, fertile, well-drained ferruginous soil are coincident, as a rule, throughout England and Wales, with low mortality from phthisis." [1]

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[1] "The Field of Disease, a book of Preventive Medicine," by Benjamin Ward Richardson, M.D., LL.D., F.R.S., etc., etc., pp. 556–558.

CHAPTER IX.

ALTITUDE.

DRYNESS AND ELEVATION WITH SPECIAL REFERENCE TO PHTHISIS—DETERMINATION OF DRYNESS—U. S. SIGNAL STATIONS RATED IN ORDER OF DRYNESS—RELATIVE BREATHING CAPACITY IN DRY AND MOIST AIR—PHYSICAL EFFECTS OF EXTREME ALTITUDE.

"DRYNESS AND ELEVATION," according to Dr. Charles Dennison, one of the most accomplished writers on climate in the United States, "are the most important elements in the climatic treatment of phthisis."[1] He bases his argument upon the statement that "an actually small amount of atmospheric moisture is the most important element in the best climates for phthisis."

This proposition he essays to prove, despite the "past theories and beliefs of the great body of the medical profession." And in order to be logical, apparently, he assumes that enervation is an essential condition of warmth and equability, and so proceeds to defend *coldness, variability,* and *stimulation*—the attributes of elevation and dryness—against enervation. He adopts the mean of inhabited climates as to changeability, as the line between variability and equability, and remarks :

"While altitude, wind, and exposure have much to do in determining the variability of a climate, . . . the principal index of this character is the actual humidity. This real humidity is chiefly governed by temperature, for the air can hold invisible vapor in a rapidly increasing amount, as temperature changes from cold to hot. From such conditions as solar influence, altitude, latitude, rain, radiation, winds, exposure, etc., the temperature of the air is determined ; and these conditions, with temperature as their index, determine the atmospheric humidity. It is almost permissible, then, to say climate is absolute humidity, so much is the latter the key to every attribute of the former." In harmony with this, he proposes to subdivide climate as follows :

1. Excessive dryness } giving variability.
2. Moderate dryness }
3. Moderate moisture } giving equability.
4. Excessive moisture }

[1] Paper read before the American Climatological Association, May 3d, 1884. New York Medical Journal, September 13th and 20th, 1884.

Taking the absolute humidity in grains of vapor to the cubic foot of air, in different portions of the United States, he finds that with very slight corrections, they can all be made to conform to the following statement, namely :

For excessive dryness, 40 per cent.

For moderate dryness, 40 to 60 per cent.

For moderate moisture, 60 to 80 per cent.

For excessive moisture, 80 per cent and over.

"As nearly as could be done, a third of the rating influence was given to each record indicating dryness or moisture, and the mean between these extremes was approximately determined to be sixty-seven per cent for relative humidity, sixty-seven per cent of saturation at the given temperature of the place for absolute humidity, to be represented in tenths of a grain of a vapor to the cubic foot of air, and forty-four and a half per cent for cloudiness, zero being no clouds and one hundred constant cloudiness."

But as absolute humidity depends upon the temperature, to avoid tedious calculations, he formulated the following rule, and adopted Glaisher's table :—

"The relative and absolute humidities and cloudiness in hundreds being known of a given place, find the grains of vapor at saturation either by working it out from the first two or by referring to the first columns in Glaisher's table,[1] and then take 40, 60, and 80 per cent of this as the dividing lines between the four divisions of climate. Then correct the absolute humidity for the place to be rated by multiplying it by 100 plus the excess of the relative humidity above the mean 67 per cent, and plus the excess of cloudiness above the mean of 44½ per cent, or by 100 minus these differences if they are below the mean. For instance, Los Angeles, Cal., has an autumn temperature of 64°, relative humidity 65.2, cloudiness 23 per cent, and absolute humidity 4.01 grains to the cubic foot. The capacity of the air to hold moisture at the temperature given is 6.54 grains. The rating divisions then are: Excessive dryness, under 2.64; moderate dryness, 2.64 to 3.95; moderate moisture, 3.95 to 5.27; and excessive moisture above 5.27 grains. The correction for relative humidity is 02, and for cloudiness 21 per cent, which gives a rating number 2.83 according to the rule. This moves Los Angeles from moderate moisture back into moderate dryness, its more appropriate position for that season of the year, while Washington, D. C., with an absolute humidity of 3.73 grains, because of both relative humidity and cloudiness being above the mean, is rated forward from moderate moisture into extreme moisture for the same season.

"In the last column (4) in this table we have the mean of relative humidity (67), the mean of cloudiness in hundredths (44½), and the mean

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[1] See table under Moisture, Ch. IV.—A. N. B.

The Rating Table determining the Means of Dryness, made up from 67 per cent of Saturation, 67 per cent for Relative Humidity, and 44½ per cent for Cloudiness, and obtainig One Third of their Sum. See Column (4).

Temperature, Fahr.	Glaisher's Table.—Weight in grains of vapor in a cubic foot of saturated air.	Sixty-seven per cent of column (2) in tenths of a grain of vapor.	Rating means of A. H., R.H. and cloudiness combined.	Temperature, Fahr.	Glaisher's Table.—Weight in grains of vapor in a cubic foot of saturated air.	Sixty-seven per cent of column (2) in tenths of a grain of vapor.	Rating means of A. H., R.H. and cloudiness combined.	Temperature, Fahr.	Glaisher's Table.—Weight in grains of vapor in a cubic foot of saturated air.	Sixty-seven per cent of column (2) in tenths of a grain of vapor.	Rating means of A. H., R.H. and cloudiness combined.
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Deg.				Deg.				Deg.			
0	0.545	3.65	38.4	44	3.32	22.24	44.5	73	....	....	56.8
2	....	....	38.5	45	....	....	44.8	74	9.10	60.97	57.5
4	0.649	5.17	38.5	46	3.56	23.85	45.1	75	....	....	58.1
6	....	....	38.7	47	....	....	45.4	76	9.69	64.92	58.8
8	0.772	5.17	38.9	48	3.82	25.59	45.7	77	....	....	59.5
10	....	....	39.0	49	....	...	46.0	78	10.31	69.07	60.2
12	0.916	6.14	39.2	50	4.10	27.47	46.3	79	....	....	60.6
14	...	....	39.4	51	....	....	46.6	80	10.98	73.56	61.2
16	1.090	7.30	39.6	52	4.32	29.42	47.7	81	....	....	61.9
18	....	....	39.8	53	...	....	47.4	82	11.67	78.18	62.7
20	1.298	8.70	40.1	54	4.71	32.56	47.8	83	....	....	63.5
22	....	....	40.3	55	....	....	48.1	84	12.40	83.08	64.3
24	....	....	40.5	56	5.04	33.77	48.4	85	....	....	65.1
26	1.674	11.22	40.9	57	....	....	48.7	86	13.17	88.24	66.0
27	....	....	41.4	58	5.39	35.98	49.1	87	....	....	66 9
29	1.892	12.68	41.4	59	....	....	49.5	88	13.98	93.67	67.9
30	....	...	41.5	60	5.77	38.66	50.0	89	....	....	68.8
32	2.13	14.27	41.9	61	....	....	50.4	90	14.85	99.50	69.8
33	....	...	42.1	62	6.17	41.34	50.9	91	....	....	70.8
34	2.30	15.41	42.3	63	....	...	51.3	92	15.74	105.45	71.8
35	....	....	42.5	64	6.59	44.15	51.7	93	...	....	72.8
36	2.48	16.62	42.7	65	....	....	52.3	94	16.69	111.82	73.9
37	....	....	43.9	66	7.04	47.17	52.9	95	....	...	75.0
38	2.66	17.82	43.1	67	....	...	53.4	96	17.68	118.45	76.1
39	....	....	43.3	68	7.51	50.32	53.9	97	....	....	77.3
40	2.86	19.16	43.6	69	...	....	54.6	98	18.73	125.49	78.5
41	....	....	43.8	70	8.01	53.67	55.3	99	....	....	79.7
42	3.08	20.63	44.0	71	....	....	55.7	100	19.84	132.93	81.0
43	....	....	44.2	72	8.54	57.22	56.2				

of absolute humidity for different temperatures (column 3) added together, and the sum divided by 3 to the mean of all. By this last, the combined mean as to dryness and moisture, all places can be compared, the average temperature, relative humidity, absolute humidity, and cloudiness of which are known for a given time. The rule is thus simplified to a rating table for all climates. For instance, Denver, for the autumn of 1883, with an average temperature of 50.4° F., has a rating mean, according to the table, of 46.3°, while the record shows relative humidity of 50.1°, cloudiness 20 per cent, and absolute humidity, in tenths of grains, 18.9. A third of these three is 29.7. Denver then stands

to the mean of the United States for that season as 27.7 is to 46.3, or 16.6 on the dry side of the mean. New York City, with temperature 53.9, has a rating number of 47.8, and with R. H. 69.9, cloudiness 51, and A. H. 32.9, gives a record of 51.3, or 3.5 on the moist side of the rating mean for the same season. Thus continuing, all the seasons for all the Signal Service Stations in the United States were rated. I then found that twelve, or 12 per cent on either side of the proper mean, would include nearly all the excesses or deficiencies. Only exceptionally moist or exceptionally dry places would exceed this limit. I therefore gave the first six excess or deficiency to *moderate moisture* and to *moderate dryness*, respectively; and the next six excess or deficiency to *extreme moisture* and to *extreme dryness*, respectively. The finally accepted *climatic rule for dryness* can then be simply stated thus:

"*With the combined mean of relative humidity and cloudiness per cent, and absolute humidity in tenths of a grain of vapor* (*column* 4), *compare one-third of the sum of the actual records given of the same attributes for any place, and the difference, plus or minus, shows the rate of the given climate.*"

In justification of this arbitrary rule giving nearly one-third of the rating influence to cloudiness, he observes: "That the Signal Service estimates all over the country, both of temperature, absolute and relative humidity, are taken *behind the blinds*, and the wonderful influence of the sun, the source of every thing that is good in climate, is literally thrown 'into the shade' by what we have hitherto trusted as climate records. This is a most important though neglected consideration, especially in the clear air of such climates as are found in the western elevated plateaux, where the powerful effect of sunshine is quickly recorded by the metallic thermometer, and its absence as remarkably noted in the shade. Were it not that sunshine so often goes hand in hand with low humidity records, I should be in favor of giving it more rather than less influence in the rating of climates.

"To still further localize each climate with reference to others in the same division, I subdivided each of the larger into three smaller divisions . . . using figures 1, 2, 3, 4 to designate the four divisions of climate, and the letters *a, b, c* the appropriate thirds in each. I had ample source from which to choose proper climates to illustrate the discriminating operations of my rule. . .

"As it is during winter chiefly that the invalid must have a change of climate, the classification for that season, according the rule, would give a very desirable table, as follows:

TABLE.

Signal Service Stations in the United States, rated in order of Dryness, according to the Climatic rule for Winter of 1883, *January, February, and December, with Mean Temperature added.*

No. in order of dryness.	Stations.	Rate.	Temperature, deg.
	OF EXTREME DRYNESS.		
1	Yuma, Arizona......	1c + 4	55.1
2	El Paso, Texas......	1c + 1	45.0
3	Denver, Colorado....	1c	28.6
4	La Mesilla, New Mex.	1c	43.4
5	Cheyenne, Wy. Ter..	1c	23.21
6	Fort Davis, Texas....	1c	43.3
7	Los Angeles, Cal	1c	54.1
8	Santa Fé, New Mex..	1c	30.1
9	Prescott, Arizona ...	1b	36.8
10	Fort Grant, Arizona.	1b	43.0
11	Pioche, Nevada	1b	30.6
12	Fort Elliot, Texas....	1a	31.4
13	San Diego, Cal	1a	54.3
	OF MODERATE DRYNESS.		
14	West Las Animas,Col	2c	23.7
15	Bismarck, Dakota...	2c	5.8
16	Fort Stockton, Tex..	2c	43.5
17	Fort Apache, Ariz...	2c	35.7
18	Camp Thomas, Ariz.	2b	43.2
19	Visalia, California ..	2a	45.2
20	Fort Maginnis, Mon..	2a	19.6
21	Salt Lake, Utah.....	2a	28.0
22	Cape Mendocino, Cal.	2a	46.0
23	Yankton, Dakota....	2a	14.5
24	Fort Assiniboin, Mon	2a	12.1
25	Winnemucca, Nev ..	2a	27.9
26	Red Bluff, California.	2a	44.6
27	North Platte, Neb ...	2a	29.3
	OF MODERATE MOISTURE.		
28	Fort Benton, Mon ...	3a	18.3
29	Omaha, Nebraska....	3a	19.4
30	Fort Sill, Ind. Ter ...	3a	39.3
31	Dodge City, Kansas..	3a	26.7
32	Fort Concho, Texas..	3a	42.8
33	Dubuque, Iowa.. ...	3a	17.5
34	Lynchburg, Virginia.	3a	38.4
35	Pike's Peak, Col.....	3a	3.1
36	Davenport, Iowa....	3a	22.7
37	Sacramento, Cal.....	3a	45.4
38	San Francisco, Cal ..	3a	48.8
39	Portland, Maine.....	3b	25.3
40	Huron, Dakota......	3b	10.8
41	New London, Conn..	3b	29.4
42	Fort Custer, Mon....	3b	21.4
43	Baltimore, Maryland.	3b	36.0
44	Des Moines, Iowa ...	3b	17.3
45	Savannah, Georgia..	3b	55.0
46	Fort Bennett, Dak...	3b	14.0
47	Fort Buford, Dak....	3b	5.0
48	Eagle Rock, Idaho...	3c	16.1
49	Boston, Mass.......	3c	28.3
50	Atlantic City, N. J..	3c	33.0
51	Chicago, Illinois.....	3c	21.8
52	New Orleans, La....	3c	57.9
53	Block Island, R. I....	3c	32.5
54	Deadwood, Dakota..	3c	20.5
55	New Haven, Conn...	3c	26.8
56	La Crosse, Wis......	3c	13.9
57	Jacksonville, Fla....	3c	58.8
58	Keokuk, Iowa.......	3c	22.7
59	Philadelphia, Pa	3c	34.2
60	Palestine, Texas....	3c	47.3
61	Fort Smith, Ark.....	3c	37.8
62	Barnegat, N. J......	3c	33.4
63	Leavenworth, Kan..	3c	26.3
64	Washington, D. C...	3c	33.7
65	Cedar Keys, Fla.....	3c	60.1
	OF EXTREME MOISTURE.		
66	Cape May, N. J......	4a	37.2
67	Olympia, Wash. Ter.	4a	37.3
68	New York City......	4a	30.5
69	Springfield, Illinois..	4a	27.0
70	Key West, Florida ..	4a	72.3
71	Little Rock, Ark	4a	43.2
72	Albany, New York..	4a	27.7
73	Vicksburg, Miss.....	4a	50.1
74	Rio Grande City, Tex	4a	60.7
75	St. Paul, Minnesota..	4a	9.7
76	Eastport, Maine.....	4a	20.2
77	Norfolk, Virginia....	4a	42.2
78	Montgomery, Ala ...	4a	51.0
79	Sandy Hook, N. J ...	4a	31.4
80	Chincoteague, Va ...	4a	36.7
81	Augusta, Georgia....	4a	50.3
82	Shreveport, La......	4a	49.0
83	Milwaukee, Wis.....	4b	19.1
84	Pensacola, Fla	4b	55.3
85	St. Vincent, Minn ...	4b	3.5
86	Indianapolis, Ind....	4b	29.0
87	Louisville, Ky.	4b	36.9
88	Chattanooga, Tenn..	4b	43.2
89	Charlotte, N. C......	4b	42.1
90	Wilmington, N. C...	4b	49.3
91	Moorehead, Minn....	4b	0.2
92	Kitty Hawk, N. C ...	4b	42.9
93	Mt.Washington, N.H	4b	4.1
94	Charleston, S. C.....	4b	52.3
95	Cape Henry, Va.....	4b	40.5
96	Toledo, Ohio........	4b	26.9

TABLE *Continued.*

No. in order of dryness.	Stations.	Rate.	Temperature, deg.	No. in order of dryness.	Stations.	Rate.	Temperature, deg.
97	Duluth, Minn........	4*b*	10.2	117	Hatteras, N. C......	4*c*	44.9
98	Fort Shaw, Mon.....	4*b*	20.6	118	Brownsville, Texas..	4*c*	58.1
99	Memphis, Tenn.. ...	4*b*	42.1	119	Oswego, New York..	4*c*	26.5
100	Smithville, N. C.....	4*b*	47.5	120	Escanaba, Michigan.	4*c*	14.8
101	Provincetown, Mass.	4*b*	30.2	121	Galveston, Texas ...	4*c*	54.5
102	Mobile, Alabama....	4*b*	53.6	122	Sandusky, Ohio.....	4*c*	31.1
103	Atlanta, Georgia....	4*b*	44.4	123	Nashville, Tennessee.	4*c*	46.5
104	Lewiston, Idaho.....	4*c*	28.5	124	St. Louis, Missouri ..	4*c*	28.9
105	Mackinac City, Mich.	4*c*	19.2	125	Pittsburgh, Pa......	4*c*	31.7
106	Knoxville, Tenn.....	4*c*	39.7	126	Roseburg, Oregon....	4*c*	39.8
107	Boisé City, Idaho....	4*c*	31.7	127	Cincinnati, Ohio.....	4*c*	34.7
108	Dayton, Wash. Ter..	4*c*	27.5	128	Cleveland, Ohio.. ..	4*c*	25.6
109	Cairo, Illinois	4*c*	36.2	129	Spokan F'lls, Wash.T	4*c*	25.8
110	Columbus, Ohio.....	4*c*	30.6	130	Portland, Oregon....	4*c*	38.8
111	Del. Breakwater, Del	4*c*	35.1	131	Grand Haven, Mich..	4*c*	24.1
112	Fort Macon, N. C...	4*c*	45.8	132	Alpena, Michigan....	4*c*	18.2
113	Marquette, Mich.....	4*c*	17.1	133	Erie, Pennsylvania..	4*c*	27.2
114	Indianola, Texas.....	4*c*	54.1	134	Rochester, N. Y. ...	4*c*	25.8
115	Helena, Montana....	4*c*	20.0	135	Buffalo, New York..	4*c*	23.9
116	Detroit, Michigan....	4*c*	26.3	136	Port Huron, Mich ...	4*c*	20.9

Dr. Denison next briefly considers the influence of temperature, altitude, latitude, the seasons, distance from the ocean, mountain ranges, absorbing power of the earth, variation, diathermancy of the air, sunshine, absolute humidity, relative humidity and dryness indicated by variability on atmospheric dryness; and concludes with citations of numerous authors, and a summary of his own observations on the physical effects of dryness. After referring to the experiments of Valentin, Sanctorius, Lavoisier, Séguin, Dalton, and others, on pulmonary transpiration, under varied conditions, he thinks that all these investigators have missed the mark he aims at—"which is to determine the amount of moisture exhaled (above that inhaled) in a dry *more* than in a moist atmosphere. . . .

"Temperature and altitude, with distance from the sea, are such powerful agents in producing dryness that it is well for us to divide our own inquiry—namely, the increased pulmonary transpiration in (1) warm dry, and (2) in cold dry air.

"First in warm dry, as compared with warm moist air. Let us choose Yuma, Arizona; and Jacksonville, Fla.; for the autumn of 1883, as they both had the same mean temperature for that season—71.3°. Dalton assumes in his calculations that the air passes from the lungs in a state of saturation, and Draper puts the dew-point of expired air at 94°. Let us assume that the expired breath brought down to 94° is saturated with vapor; that an ordinary-sized man breathes eighteen times a minute (Quetelet) and expires twenty cubic inches at each breath when at rest (Hutchison,

Flint, and others); that he breathes the same amount of air in Jacksonville as in Yuma, and that the loss by breathing of $\frac{1}{10}$ to $\frac{1}{50}$ in volume (Davy and Cuvier) is made up by the expansion of the air in the lungs being raised from 71.3° to the heat of the body. We have then the following calculation:

Autumn.	Yuma.	Jacksonville.
Mean temperature	71.3°	71.3°
Weight of vapor with air saturated (Glaisher)	8.33 grains.	8.33 grains
Mean relative humidity	.428	.774
Air breathed in 24 hour	300 cubic feet	300 cubic feet.
Vapor inhaled in 24 hours	1,070 grains.	1,924 grains.
Vapor exhaled in 24 hours, with dew-point at 94°	5,007 grains.	5,007 grains.
Vapor exhaled more than inhaleled in 25 hours.	3,937 grains.	3,073 grains.

Excess for Yuma over Jacksonville, 864 grains a day.

. . . "Crawford has shown by experiments that the exhalation of carbonic acid from the lungs is much greater in low than in high temperatures, and Draper says twice as much carbonic acid is liberated with a temperature at 68° as at 106, while Lehmann [1] has likewise shown that exhalation of carbonic acid is greater in a moist than in a dry atmosphere, temperature remaining the same.[2] Therefore we are compelled, in order to favor the exhalation of carbonic acid, to take our dryness with a favorable cold temperature. This leads us to the more important comparison—that between warm moist and cold dry air. It is here that altitude, distance from the sea, etc., come in, as they produce both the coldness and the dryness we need.

"Let us choose Denver and Jacksonville for the autumn of 1883, and give Denver the benefit of one-fifth greater amount of air breathed, the air there being about one-fifth rarefied. This will account for the deeper and more frequent respirations and the corresponding greater activity of the heat in ordinary life, but not for the greater increase under severe exercise, like climbing hills, etc.

"We will assume as breathing in both places a good-sized man, thirty years old, breathing eighteen times a minute at sea-level, and expiring an average of thirty cubic inches (Dr. Gréhaut), ordinary exercise included:

[1] "Physiological Chemistry," Philadelphia, 1855, vol. ii., p. 414.

[2] Dr. Lombard, of Geneva, in a paper presented to the International Congress of Hygiene, September, 1882, concludes that "in the altitudes the digestion, the muscular exercise, and the lowering of the temperature increase and accelerate the exhalation of carbonic acid."

Autumn, 1883.	Denver.	Jacksonville.
Mean temperature.	50.4°	71.3°
Weight at saturation for given temperature grains in a given foot.................... ..	4.44	8.33
Mean relative humidity............	.501	.774
Amount of air breathed in 24 hours...........	933,120 cub. in., or 540 cub. it.	777,600 cub. in., or 450 cub. ft.
Vapor inhaled in twenty-four hours...........	1,461 grains.	2,901 grains.
Vapor exhaled in 24 hours at 94° dew-point ...	9,013 grains.	7,510 grains.
Vapor exhaled above that inhaled in 24 hours.	7,552 grains.	4,599 grains.

Denver's excess in transpiration, 2,453 grains, or $5\frac{5}{8}$ ounces, or $1\frac{2}{5}$ gills.

"This would amount to over six ounces or one and a half gill, if the considerable expansion of the air in being raised in the lungs from 50° to 98° is accounted for at Denver.

"Denver and Cedar Keys, compared in the same way for last winter (1883–84), results in 2,935 grains, or $1\frac{2}{3}$ gills more moisture being exhaled from the lungs in Denver than in Cedar Keys."

"Now, I wish to ask," Dr. Denison queries in conclusion, "Does it not stand to reason that this transpiration of surplus vapor is a most admirable vehicle for carrying away effete matter, wasted tissue, and the germs of disease (bacilli)? Is it a wonder that thirst for fluids, an appetite for food, as well as the ability to digest it, are greatly increased in all those who, coming to the elevated interior of our continent, can stand the strain without disturbance of the nervous system?

"If the foregoing conclusions are reasonable, can you not imagine the decided influence, especially upon the respiratory activity and function, caused by climbing the hills and mountain-sides in Colorado, when 'one at sea-level, walking at the rate of three miles an hour, consumes three times as much air as when at rest' (Dr. Edward Smith)?"

The foregoing theories and conclusions of Dr. Denison are given, not because we indorse them, as may reasonably be inferred from what we say, further on, of the salubrity and *tonic* effects of the atmosphere at sea and in forests, where it is essentially humid, but for the special value of his deductions and classification of the climates of the United States according to their relative degrees of humidity.

As still further illustrating the physical effects of altitude and dryness, with a view, to its wholly impartial consideration from a strictly scientific point of view, under the most extraordinary circumstances, the following extract from an official report by Medical Inspector, Benjamin F. Gibbs, U. S. Navy, on the Medical Topography of the Pacific Coast of South America, will not fail to be of interest and practical utility.

"The medical topography and climate of this west coast present many peculiarities which excite continually, in the mind of the medical traveller, an unfailing interest, on account of their direct and visible

effects upon the animal economy. The climate of the city of Arequipa is peculiarly dry, on account of its situation amid the surrounding desert of Atacama, and cold on account of its altitude of 8,000 feet. These peculiarities give the city some celebrity in both Chili and Peru on account of some wonderful cures which are said to have occurred there, of persons who had suffered from tubercles of the lungs. I have known several apparently hopeless cases recover after a residence there of only six or eight months, and then return to their homes in Chili. The fine stream of water which runs through the city causes the soil which is irrigated by it to yield abundantly, so that the supply of good wholesome food is abundant, and which must always be taken into consideration along with other comforts when persons who are suffering from consumption of the lungs are seeking the benefits of a change of climate.

"Arequipa resembles in climate another place in Peru, the town of Jauja, which is situated about 120 miles east of Lima, and beyond the western Cordillera. The place contains about 15,000 inhabitants of mixed races, enjoys a bracing climate, and is the great sanitarium of the Peruvian capital. Its clear blue sky covers this mild climate, and a temperature never varying from 50° to 60° Fah. Dr. Fuentes, of Lima, says Jauja has always been the refuge of consumptive patients, and lengthened experience has demonstrated the favorable results of this climate. The proportion said to have recovered, of the total number of patients sent to Jauja, amounts to 79½ per cent. In view of so favorable a result, the government initiated there, in 1860, a hospital for consumptives, but which never reached any degree of perfection on account of financial embarrassments.

"Among other peculiarities of climate are those causing the "*aire*," and which are, perhaps, more strikingly exhibited in Peru than in Chili. A most singular illustration of its effects was given me by Dr. Heath, who is the surgeon employed on one of the Peruvian railroads now building from Packasmayo to the Andes. While making this trip over the road with him, he informed me that the visible effects of this existing cause were quite common in his experience. He mentioned an incident he witnessed far up on the line of this road. He experienced, one day, as he approached a party of workmen on the road, a severe and sudden pain in his side, causing him to "double up." He, however, managed to walk on, and one of the workmen hailed him to stop and see several men who were ill, and had been taken that instant with severe pains, etc. What was still more wonderful in his statement of coincidences, but which has since been vouched for by others, was, that at the same moment he felt this pain he saw two birds, which were flying over, fall to the ground, and were picked up dead. The ordinary effects of *aire* are a paralysis of the cutaneous nerves and redness of the skin from dilatation of the capillaries. This effect on man might, if exerted upon a bird, produce sufficient shock to cause death.

"It is not astonishing to see a result of this kind realized, when we consider that Packasmayo is almost under the equator. It is subjected to a temperate climate, while it is under the influence of a torrid sun. Could anything be better arranged to evolve strong electrical currents where such positive degrees of heat and cold meet on such sharp lines? The strata of air indeed, under such circumstances, must exist in various directions and in wild contortions. The most natural arrangement one would conclude to exist is that the alternating strata of hot and cold air rest, as it were, on their edges, their length running north and south, in the direction of the isothermal lines. Were such the case, the least undulation of such long flowing lines, defined by such sharp boundaries, would deflect at one time cold and at another hot air upon an animal structure, causing violent reflex action, shock, paralysis, or, as in the above instance, the death of the birds. These intense effects, be it observed, occur usually at great altitudes, the milder effects at a lower level.

"I must hasten to notice the special effects of the rarefaction of air in the localities in question upon the animal economy, as has been illustrated and most satisfactorily studied during and since the construction of the Oroya Railroad by Mr. Henry Meiggs, the only one in the world reaching the altitude of 15,640 feet. I give the following particulars regarding the effects of rarefied air from my own experience on this road, and from the written and oral statements of Dr. G. A. Ward, who has been employed professionally on the road since its beginning.

"The labor employed in building this road was principally the native Peruvians of the mountains, who are a short, thick-set race called Serranos, and have immense lung capacity. Mr. S. W. North, civil engineer, made some measurements of these Serranos at Yauliyacu, an altitude of 16,000 feet, as follows:

Age.	Chest measurement.	Height.		
		Proper height in inch. of twice the chest measurement, European standard.	Actual height in feet and inches and in inches alone.	Difference in inches.
	Inches.	Inches.	Ft. in. in.	
14 years	36	72	4 10 = 58	14
24 years	36	72	5 6½ = 66½	5½
21 years	35	70	5 4 = 64	6
16 years	34½	69	5 0 = 60	9
30 years	34½	69	5 4½ = 64½	4½

Average difference in height between European and Serrano, 7⅘ inches.

"This enormous increase in size of the chest is owing to the rarefaction of the air in which these natives live, enabling them to undergo an active, and even laborious, existence at these great altitudes. American engineers employed in building the road increased their lung capacity during their labors. One of these, Mr. John Malloy, informed me that the measurement of his chest had been increased four inches in two years by exposure to rarefied air in these Andes.

"This peculiarity of adaptation to the demands of nature enables these people to overcome the pains and inconveniences which are experienced by persons who ascend the Andes for the first time toward their summits, and which are known under the names of *soroche, veta, puna,* etc. These symptoms indicate a diminished supply of oxygen, but more particularly a diminished pressure of air on the surface of the body and on the interior of the lungs.

"The pressure at the sea-level constantly diminishing as you ascend, is found to be reduced to about one-half at an elevation of 16,000 feet, or the summit tunnel of the Oroya Railroad. This withdrawal of pressure often occasions the most severe symptoms of vertigo, headache, nausea, and vomiting, all more or less alarming, and attended with profound prostration. The whole are attended with increased respiration and rapid action of the heart. Dr. Ward says some are affected with fearful nausea and vomiting, comparing it to the worst form of sea-sickness. Others suffer from severe frontal headache, palpitation of the heart, etc. From the violence of the heart's action it really seems at times as if it would burst the walls of the chest. Occasionally severe hemorrhage occurs from all the avenues of the body.

"The respirations are increased from three to five times a minute. Dr. Ward says he has counted 43 respirations and 148 pulse in a minute at an elevation of only 9,000 feet, and that the pulse is *always* increased in frequency but not in volume. A person who, at the sea-level, has a pulse of 75 per minute, would find it increased about ten beats at an altitude of 10,000 feet, and would experience ten additional beats for each 1,000 feet of added altitude. The rule is that no one passes for the first time an altitude of 16,000 feet whose pulse does not mount to from 130 150 beats in a minute.

"These increased numbers of pulsations are absolutely necessary to avert a fatal result. The attending increased respiratory action is not accompanied with increase of secretions, but an increased amount of air of inferior quality, from actual reduction of the amount of oxygen, fails to aërate or properly preserve the fluidity of the blood.

"Most persons, I feel convinced, attach an undue importance to the actual diminution of the quantity of oxygen, *per se,* required by the human and animal economy generally, resulting in *soroche.* We know that animal life suffers no such violent symptoms as are constantly exhibited in *soroche,* when it is at times deprived of a large proportion of

its oxygen, as under battened hatches on shipboard, or when air is surcharged with smoke or steam in which people are obliged to live at or near the sea-level. It must be remembered that symptoms of *soroche*, above described, overtake one as he sits quietly in a comfortable car, or more frequently at night. It is one of the peculiarities of this affection that one may go to bed feeling not the slightest inconvenience, and will be awakened at midnight with the most agonizing headache, vomiting, and a gasping for breath which seems to point to impending suffocation.

"A better explanation, it seems to me, and one which more completely explains all of the symptoms, may be found by ascribing more of the cause to a withdrawal of the pressure from the body. The immense reduction of one-half the accustomed pressure from the body within a few hours allows a determination of blood to the viscera and extremities, so that there is actually less blood in active circulation, and the contractions of the heart are probably made when that organ is but partly filled with blood. This would account for the increased action of the heart, without seeking a more important or satisfactory cause in the loss of oxygen due to a rarefied condition in the air.

"With this withdrawal of blood to the capillaries, it is easy to account for headache, nausea and vomiting, syncope, and other threatening symptoms derived from the brain and nervous centres. We must, hence, regard the brain as being in an anæmic condition, and is thus denied its usual stimulus on account of being inclosed in its rigid bony case, where the direct influence of the withdrawal of external pressure is not felt, as in the other soft parts of the body. The co-ordinating power of the brain is thus lost in consequence of the distant distribution of the blood to those organs which are directly affected by the removal of external pressure, and in which an *increased* supply of blood produces no disturbance of function beside that of mechanical distention. Hence all of those painful symptoms which are referable to the anæmic condition of this part of the vital tripod.

"Dr. Ward says the persons most disposed to *soroche* are those with a large amount of blood in the body; for example, stout, florid, muscular men usually suffer most severely. A popular illusion regarding *soroche* is that persons with large lungs are less liable to it than those with small, feeble lungs. The special liability of stout, large-chested men to *soroche* is most satisfactorily accounted for, if we admit that the removal of the external pressure is the principal factor in producing this affection. The large expanse of surface and large viscera, by becoming temporary receptacles for an increased amount of blood, act by withdrawing so much from the active circulation, causing direct anæmia of the great nerve centres. The brain is no longer a *plenum*. The heart is deprived of its normal stimulus, and in its enfeebled condition resorts to increased action to supply urgent demands in the economy, but not for an increase of oxygenated blood particularly.

"An instance is related of a party which passed an entire year at Galera, which is the summit tunnel of the Oroya road, and has an elevation of 15,645 feet. This party of engineers, upon visiting Lima, all suffered severely for several days before becoming again accustomed to the dense air of the sea coast. The theory of Dr. Ward and others, in attributing this suffering to a change in the quality of the air, whereby an excess of oxygen was introduced into the blood, would not account for the syncope in his own case in Lima, where there was a sudden call by telegraph for his services, which obliged a descent of 16,000 feet in two hours. His theory, that in this descent there is a "liability of the air-vesicles to collapse, and the retention of foul matters within them as a cause of disease," is hardly tenable, because an increase of density provides an increase of oxygen, and an increased aëration of the blood within defined limits; so that the increase of vesical surface acquired by residence in an attenuated air could exert no other than a proper result, even were the transformation of a reduction of surface to be wrought instantly. A considerable period might elapse without any reduction of this increased aërating surface, and without any injurious effect.

"Supposing a denser air to be breathed, no increased quantity of oxygen would be absorbed, as it has been demonstrated that in breathing an increased quantity of oxygen gas no more is used in the lungs than is necessary for the production of watery vapor and carbonic acid gas in eliminating carbonaceous matter from the blood.

"But after making this sudden descent, which is often done in a hand-car, at the rate of forty to sixty miles an hour, by resorting to the theory of increased pressure upon the body, the symptoms are more satisfactorily explained. The long residence at the summit provoked an increased vital contractility, which is inherent in all vital tissues, and pre-eminently in the dermis. This increased vital power, which is demanded to complement the loss of air-pressure, upon descending to the sea-level remains unaltered. The air-pressure being now added to this peripheral tone of the body causes a centripetal determination of blood, which is felt acutely by the brain and all the nerve-centres. The syncope, increased respiration, and palpitation may be thus accounted for. The reduction, as it were, of the size of the body in the vascular system demands, on account of mechanical congestion of all the viscera, an increased action in the heart and lungs, whereby the blood may be rapidly aërated and rapidly passed off by the secreting and excreting surfaces. The resort to purgatives and depleting measures, under the effects of a rapid descent, is beneficial, which is a therapeutic indication of the correctness of my theory, and which I never have seen before explained."[1]

[1] "Hygiene and Medical Reports by Medical Officers of the U. S. Navy." Vol. iv., 1879, pp. 269–277.

CHAPTER X.

ATMOSPHERIC PRESSURE.

THE influence of changes in the weather on the sensations of persons afflicted with some diseases, preceding rainfall, has long been recognized, and since the discovery of the pressure of the atmosphere and of the barometer with which that pressure is measured, the knowledge of a close connection between the fall of the barometer, and painful sensations experienced by persons afflicted with rheumatic and neuralgic diseases, has become general. But the true relation of the fall of the barometer to such painful sensations was first clearly explained by Dr. Andrew H. Smith, of New York, in his study of the "Caisson Disease," during the early progress of the East River Bridge.[1]

Under the ordinary pressure of the atmosphere, fifteen pounds to the square inch of the surface of the body, all the functions of life are naturally exercised. When compressed air first began to be employed in the sinking of piers, about thirty-five years ago, it was soon observed that when workmen were exposed to these pressures, they were subject to peculiar physiological changes. The blood in their veins became of the same red color as that in their arteries, the respiration was quickened, the action of the skin was profuse ; and when the men returned to the ordinary pressure of the atmosphere, they suffered with pain in their limbs, giddiness, and other symptoms of nervous disturbance ; insomuch that the period of labor had to be very much shortened. Taking ten hours as the standard time for a day's labor, it was reduced under two atmospheres to half time, or five hours; under three atmospheres, to one-third time, or three hours and a half ; and under four atmospheres, to one-fourth time, or two hours and a half.

In the East River Bridge caisson, at the beginning of the work, the pressure of the air necessary to keep the water out—which pressure increased in exact proportion to the depth—was about eighteen pounds to the square inch, while at the close of the work it stood at thirty-six pounds. As the depth increased, the hours of labor were reduced, until

[1] "The Effects of High Atmospheric Pressure, including the caisson diseases." Prize essay of the Alumni Association of the College of Physicians and Surgeons, New York, 1873. By Andrew H. Smith, M.D., Surgeon to the New York Bridge Company, Member of Academy of Natural Sciences, Philadelphia, etc., etc.

at last the two shifts comprised but four hours, divided by four hours interval. It was not until the pressure had reached about twenty-four pounds that any serious effect upon the men was observed. All who were suffering from heart or lung disease, and those enfeebled by intemperance were excluded, and rigid health rules were exacted in regard to diet, temperance, sleep, etc., when off work; and allowing no workman to enter the caisson who was at all sick. Their ages ranged from eighteen to fifty. The habits of many of them were unfavorable to health, but everything practicable was done to restrain them from excesses.

The physical conditions to which the men were subjected in their work were very peculiar. In the first place, in passing through the lock in going down, there was a very sudden rise of temperature from the condensation of the air. This rise amounted to upwards of 30° F. in many cases, and not infrequently, when the outside temperature was 50° or 60°. This change of temperature was coincident with an increase of atmospheric pressure of from eighteen to thirty-six pounds to the square inch. At the same time, the men passed from an atmosphere of unusual dryness to one saturated or super-saturated with moisture. The effect of this, Dr. Smith observes, was:—

"The clothing quickly became saturated, but a little examination served to show that in the New York caisson, at least, there was really no increase of the secretion from the skin, but that, instead of evaporation, the moisture accumulated upon the surface, and thus simulated excessive sweating. This was owing to the moist condition of the atmosphere, which rendered the drying of the surface by evaporation impossible. The atmosphere possessed to an extreme degree the quality of "mugginess," and the apparently profuse perspiration was merely an exaggeration of what we suffer from in very damp weather, even though the temperature be not extreme.

"So far from the perspiratory glands being stimulated by the density of the atmosphere, it is probable that the anæmia of the skin, resulting from the pressure upon the surface, would tend to lessen the secretion by diminishing the supply of blood to the glands; and that there was no undue amount of fluid carried off through the skin was shown by the absence of thirst. Special importance is attached to this observation, of the apparent increase of perspiration only, as bearing upon the theory of excessive waste of tissue, in which the perspiration is supposed to aid."

With respect to the effect of compressed air on the digestive organs, for a time at least, Dr. Smith's observations are in accord with others—that the appetite is increased to a marked extent. It was frequently remarked by the men working in the Bridge caisson, that their work made them unusually hungry, that they "could not get enough to eat, etc."

The "caisson disease" Dr. Smith defines to be *"a disease depend-*

ing upon increased atmospheric pressure, but always developed after the pressure is removed. . . . The one essential cause, without which the disease can never be developed, is *the transition to the normal atmospheric pressure, after a prolonged sojourn in a highly condensed atmosphere.* Hence we have to consider two elements, *pressure* and *time.* As the momentum of a moving body is found by multiplying the weight by the velocity, so the danger in these cases is as the degree of pressure to which the person has been exposed, multiplied by the duration of the exposure.

"But inasmuch as a prolonged sojourn in the caisson does not in every case produce the disease (many of the men employed escaping it entirely), it follows that there must be concurrent causes which determine its development. This is what we observed in many other diseases of specific origin. Thus the essential cause of intermittent fever is exposure to a peculiar malaria, yet only a portion of those so exposed are affected by the disease.

"The first of the concurrent causes of the caisson disease is a *special predisposition.* This is occasionally strongly marked, some persons being affected by a short exposure to a low pressure from which there would generally be experienced no inconvenience whatever.

"The study of these cases has led me to the suspicion that they afford a key to the singular, though very common, predisposition to pains in the limbs on the approach of a storm. These pains are generally considered to be of a rheumatic character, and to depend upon the dampness of the atmosphere. But inasmuch as the disease we are considering affords examples of pains precisely the same in character, but immensely intensified in degree, resulting from a diminution of an atmospheric pressure to which the system had adapted itself, and irrespective of any question of humidity, analogy suggests that the so-called rheumatic cases are simply exaggerations of a predisposition, identical in kind with the one under discussion, and are produced by the low barometric condition of the atmosphere which precedes a storm, and not by the influence of moisture. It is true that the change in the pressure is insignificant when compared with that which produces the caisson disease, but it is supplemented by the immensely greater duration of the higher pressure to which the subject has been previously exposed. Persons suffering in the manner referred to, regard themselves as walking hygrometers, and are accustomed to say, 'I feel the *dampness* in my bones.' I would suggest that they are rather barometers, perhaps quite as sensitive as the instrument of Torricelli."

Upon this reasoning and other inferences which he has drawn from his researches, Dr. Smith explains why some cicatrices, such as those following gunshot wounds, are especially prone to neuralgic pains during change of weather. He also explains why, on bright days, when the air is clear and the barometer is high—that is to say, when the greater at-

mospheric pressure on the surface drives the blood into the interior of the body, and especially into the organs in closed cavities, such as the brain, the mind is active and the muscles vigorous; while, on the contrary, on damp, foggy days, mental effort is irksome, the limbs drag, the appetite poor, and the whole tone of the system lowered.

Dr. Benjamin Ward Richardson, in commenting upon Dr. Smith's observations, remarks:

"The changes are more distinctive still in those who are prone to disease, and in whom the vessels are already enfeebled or changed in structure. There can be no doubt that the effects of reduced pressure tell with intense force on large populations who are already enfeebled. . . .

"Whether the variation from high to low pressure ever acts as a primary cause of disease it is impossible to define, but that it acts as an exciting cause of the most serious character, on persons predisposed to disease, there can be no doubt whatever. A sudden reduction of the atmospheric pressure, which means a fall in the barometer, is attended with risk of pressure of blood, leading to pressure on nervous fibre and production of pain; to internal congestion, to fever, to apoplexy; while an increased pressure, which means a rise in the barometer, is attended with greater risk of injury from physical or mental shock.

"The effect of the variation extends in yet another direction," as pointed out by the same author in an essay on "Meteorology in Relation to Surgical Practice," "that the atmospherical pressure plays an important part in the results of surgical procedures, and that with a falling barometer the chances of success are reduced." [1]

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[1] "The Field of Disease, a book of Preventive Medicine." By Benjamin Ward Richardson, M.D., LL.D., F.R.S., etc., p. 552.

CHAPTER XI.

SEA-COAST PLACES AND OCEAN AIR.

INSULAR AND SEA-COAST PLACES—WARM MOIST CLIMATES—SEA-AIR PROPER—RATIO OF DEATHS FROM CONSUMPTION TO OTHER DISEASES AMONG SEAMEN—SPECIAL BENEFIT OF AN OCEAN ATMOSPHERE TO CONSUMPTIVES—OZONE IN OCEAN AIR—PURITY OF OCEAN AIR AND ITS GENERAL SALUBRITY.

THE air of insular and sea-coast places is essentially damp, and if such places are beset with accumulated débris and a filthy soil, they are unhealthy in the extreme. But on the contrary, if they are free from local contaminating influences and subject to excessive rainfall, and so situated as not to be exposed to winds that trend with the coast, though the atmosphere be never so damp, such places are not commonly insalubrious. Indeed the heavy rains of some sea-coast places are greatly contributive to the purity of both the atmosphere and soil; and in *cold* latitudes especially, the moderating influence of the sea on the temperature renders them not only more endurable, but, as measured by results, more salutary for invalids affected with pulmonary diseases than the dryer, colder, and more variable temperature of interior places of the same latitude.

The northeast winds of the Atlantic States are insalubrious, because they sweep down the fogs and mists of a northern sea-shore. But, on the contrary, the southeast and southerly winds are clean and healthy, because they are from the warmer latitudes and from the pure surface of the ocean.

Warm insular and sea-coast places, with a clean soil and devoid of organic matter in process of putrefaction, are commonly free from pulmonary diseases, and generally healthy. Countries thus favorably situated are proverbially associated with the personal beauty of their inhabitants, and are in all ages more or less celebrated for the beauty of their women. But this characteristic is chiefly confined to the warm climates of temperate latitudes.

In tropical climates, development is more rapid, the period of puberty earlier, and the beauty of childhood marked; but the beauty of the child in such climates is not unfrequently merged into a womanly beauty of very short duration. And in localities where the atmosphere is moist

and very hot, the inhabitants are usually of feeble physique, and particularly prone to liver disease. On strangers the effect of a moist *hot* climate is one of intolerable lassitude and depression.

SEA-AIR is remarkable for its salubrity, notwithstanding its humidity, and some of the insular and Gulf-coast places of the United States, with prevailing southeastern and southerly winds, approximate the conditions of an ocean atmosphere. But sea-air proper, that is to say, the ocean atmosphere, is generally less damp than the air of sea-coast places, however favorably they may be situated. For example:

"The mean relative humidity of the air at noon, as observed during a voyage from Melbourne to London, *via* Cape of Good Hope, was found to be 77 (100 representing complete saturation), while in a dry locality in the neighborhood of London the mean for the year, as recorded in 'The Weather of 1880,' by Mr. Mawley, was 83. But this, Dr. Wilson remarks, 'represents the mean of three observations taken respectively at 9 A.M., 3 P.M., and 9 P.M. A fairer comparison would therefore be with the mean of the three-o'clock observation, which for the year gave 71.5.'"[1]

But there can be no question as to the general truth that the ocean atmosphere is considerably more moist than the air of corresponding latitudes on the land.

Observations of our own, covering a period of six months, from June to November, inclusive, 1852, during a cruise on the West Coast of Africa, extending from Porto Praya, Cape du Verdes Island, to Monrovia, along the coast south to St. Paul de Loando, seaward to St. Helena and back to the Cape du Verdes, give a difference, between the dry- and wet-bulb thermometers, recorded at 8 A.M., 12 M., 4 and 8 P.M. daily for the period:

Maximum 6.20°. Minimum 0°. Mean 3.38°.

The maximum was at the Cape du Verdes, and saturation, during rains while on the coast. But singularly, the largest average number of persons on the sick-list was during the time of the least atmospheric moisture while at Porto Praya.

It is interesting to observe in this connection, and germane to the effects of atmospheric moisture in an unhealthy climate, that cruising was uniformly accompanied by a reduced sick-list, and that the healthiest ship in the squadron was the one which was at sea for the largest proportion of her time—the "Dale."

Out of a total force of 750 in the squadron, there were 1,661 cases of disease treated in two years; 9 or .54 per cent were for phthisis pulmonalis. The number of deaths was twelve—none from phthisis.

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[1] "The Ocean as a Health Resort," etc., by William S. Wilson, L.R.C.P. Lond., M.R.C.S.E., p. 9.

Medical director Thomas J. Turner, U. S. Navy, has kindly furnished the author with the following:

Abstract of Vital Statistics, showing the Ratio of Death from Phthisis Pulmonalis to Deaths from all Causes in the United States Navy for ten years.

Year.	Force.	Cases Treated.	Total Deaths.	Cases of Phthisis.	Deaths from Phthisis.	Per cent of Deaths from Phthisis to Deaths from all Causes.
1873	12,723	8,837	55	55	4	7.27
1874	13,860	9,995	64	62	7	11.03
1875	10,141	7,832	49	76	6	12.27
1876	11.138	7,797	41	38	3	7.31
1877	7,461	6,748	125[1]	44	....	....
1878	7,806	6,873	53	53	2	3.77
1879	10,388	10,284	36	55	2	5.55
1880	10,235	9,752	28	49	1	3.57
1881	11,118	9,483	28	50	1	3.57
1882	10,631	8,911	44	59	1	2.27
1883	9,874	8,722	45	41	1	2.22
				Average for ten years,		5.87

It may perhaps be objected by those who are disposed to regard a moist atmosphere as predisposing to consumption under all circumstances that such results as the foregoing are any evidence whatever to the contrary—that the navy represents picked men who are ascertained to be free from predisposing causes. But it should be borne in mind that, according to the most reliable statistics, only about one-fourth of all cases of phthisis are found to be hereditary—three-fourths of the cases are acquired by the manner of life; and the life of the seaman, especially that portion of it which he spends on shore, free from the constraints of ship discipline and the involuntary benefit of a sea atmosphere, is not such as to promote his exemption. And, unfortunately, many physicians, as well as other people, seem to have jumped to the conclusion that because it has been shown that a filthy, cold, *soil*-moisture predisposes to consumption, safety is to be found only in an excessively, or at least relatively dry atmosphere, beset by no matter what complications. But so far as statistics are obtainable, evidence is wanting to substantiate such a conclusion.

According to Wilson, in England,[2] "the registration returns of deaths amongst sailors of the mercantile marine show that the proportion of

[1] 100 drowned by loss of the "Huron."

[2] Op. cit.

deaths from consumption, as compared with those from other causes, is *ten times less* than it is amongst the English land population. But if we take only the deaths that occur between the ages of fifteen and forty-five (the usual period during which sailors remain at sea), we shall find the result still more favorable—the proportion of deaths from consumption as against those from all other causes being *sixteen times less* at sea than on land.

"Next as to the remedial effects of the ocean climate in the treatment of consumption, Dr. Theodore Williams has published statistics of eighteen cases in which the sea treatment received a thorough trial. Of these eighteen cases, sixteen improved, one remained stationary, and only one became worse. As some explanation of the extremely favorable results shown in this series of cases, it should be mentioned that the patients were carefully selected for treatment by physicians of great experience, and that several of them made more than one voyage.

"With regard to thirty-eight cases of consumption which have come under my own observation, the results were as follows: 28 improved, 4 remained stationary, 3 became worse, and 1 died. These cases were by no means selected. In some of them the disease was very far advanced—this was particularly the case with the three cases which became worse during the voyage. As regards the case that ended fatally, the patient had been for some time in the colonies, and was being sent home without any reasonable hope of his living to reach his destination. But even including these four cases which ought not to have been sent to sea at all, the results are most encouraging and will compare favorably with any series of cases treated in the most favored health resorts on shore. . . .

"Scrofulous affections of the joints and glands, and all kindred affections, may, in certain stages, be most successfully treated by means of a sea voyage. It would, of course, be inadvisable to send a patient to sea while suffering from the more acute forms of joint disease, as the constant surgical attention and the many appliances and comforts required by the sufferer could scarcely be obtained on board ship. But when the more active symptoms have subsided, and, as is so often the case, the disease assumes a chronic form, the slow and tedious convalescence may, in suitable cases, be wonderfully hastened by a sea voyage of some duration."

Dr. Benjamin Ward Richardson remarks that: "The influence of a seafaring life as a preventative of phthisis has been matter of important observation. In 1856, Bowdin showed that while the deaths from consumption in the British army were, in the Line, 8.9 in 1,000 men; in the Guards, 12.5 in 1,000 men; in the British Navy, from 1830 to 1856 inclusive, the deaths from phthisis were 1.76 in 1,000 men.[1]

[1] Op. cit., p. 558.

Various nervous affections, the effects of over-work and debility of mind or body, are also among the conditions for which a sea voyage, at least, if not a prolonged exposure to an ocean atmosphere, affords superior benefit.

Unfortunately, in the United States, except those above given from naval sources, there are no records of any value on the vital statistics of mariners.

"The term seaman, wherever employed in legislation relating to the Marine Hospital Service, shall be held to include any persons employed on board, in the care, preservation, or navigation of any vessel, or in the service, on board, of these engaged in such care, preservation, or navigation."[1]

The Marine Hospital Service reports comprehend all cases of disease treated—including women and children and servants, of and from among all persons employed as river boatmen, ferrymen, canal boatmen, etc., and their families, as well as seamen; of persons, in short, subjected to conditions in conflict with health probably unequalled by any other avocation. Notwithstanding, so far as can be gleaned from the reports of the Marine Hospital Service for the last ten years, the ratio of deaths from consumption to other diseases among these people is about 15 per cent—considerably less than that given by the census reports of the New England States and of some others.

Besides an excess of moisture, compared with the mean of 0.84 volumes, the ocean atmosphere contains at all times more or less of infinitesimally divided particles of sea salt. Yet, considering the purity of the vapor and the perfect solubility of the salt, it is difficult to conceive of any possible state of the human system under which the inhalation of such air would be detrimental. But, on the contrary, as already shown, in some of its states, the constant inhalation of these particles, containing, as they do, the important constituents of sea-water, is well adapted to produce very salutary, and in most cases of chronic pulmonary disease, decidedly beneficial effects.

Cold and heat are much less intense and oppressive in the same latitudes at sea than on land, and there is much greater equality of temperature for night and day. In the open sea the temperature of the air has never exceeded 86°.

Moreover, the higher electrical state of, and the more constant presence of ozone in, the atmosphere, the complete absence of suspended matters, barring certain exceptional regions, and the more common prevalence of the winds than on land in the same latitudes, all contribute to the general salubrity.

The winds are a fertile source of health, because they serve to equalize temperature and to scatter pernicious effluvia and condensed vapors,

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[1] Revised Statutes, 1875, Chap. 158, Sec. 3.

though they may in some cases be unfavorable, according to the region over which they pass, from which they set out, or the suspended matters which they contain. The writer has himself seen the whole atmosphere tinged of pinkish color by the dust-laden winds over two hundred miles from the land on the west coast of Africa. The dust in the air of the high altitudes of some of our Rocky Mountain and Pacific States (more particularly noticed further on) is a scarcely less prominent example. The simoon of Africa and the sirocco of Italy also owe their characters to the condition of the localities over which they pass.

But, notwithstanding these exceptional cases where the winds are the media of pernicious influences, and to a certain extent favorable to the development of disease in places distant it may be from their prime source, their general benefit is universal. For miasm once effectually "scattered to the winds" is in a gulf of destruction only as complete as that which attends human beings in windless abodes.

The influence of the ocean air-currents is most powerfully felt far out at sea in the trade-wind regions. Differing as these winds do in many respects from anything that is experienced on the land, it is not surprising that they should, as they do, impress upon many persons an exhilarating effect peculiar to themselves. To many nervous invalids, especially the "champagne atmosphere of the trades," as it is not inappropriately called, is a tonic and stimulant of the most powerful kind, scarcely attainable by any other means.

In short, sea-air proper possesses no deleterious qualities whatever. The bracing and hardening effects of it are proverbial of seamen of good habits the world over.

The ill effects sometimes attributed to sea-air are either owing to bad habits or to the want of ship-ventilation and due regard to cleanliness. For on board ship, as everywhere else, no truer maxim can be acted upon than that the want of purity is the want of health.

Light is a collateral benefit of sea-air; and doubtless not a little of the rigidity of tissue and hardiness which characterizes the sailor is owing to the influence of light. Free access of light favors nutrition and regularity of development, and contributes to beautify the countenance; while deficiency of light is usually characterized by ugliness, rickets, and deformity, and is a fruitful source of scrofula and consumption in any climate.

Light is among the most important, and yet one of the most commonly neglected conditions of a healthy life. This neglect is doubtless due to the intimate relations of light with pure air. To fully appreciate this relation, it is only necessary for us to remember that thickly shaded and dark places, and dwellings so situated as not to admit the sunlight, are commonly unhealthy.

Plants deprived of light become white, and at the same time acquire an excess of water in their tissues, which renders them tender and brit-

tle. This is specially evident in celery, with which all are familiar. It is equally so with other vegetables, and the grass and weeds on the shady side of fences and under ledges of rocks, if the sunlight is excluded, are always imperfectly developed, weak, and sickly, and rarely bear flowers or fruit.

Edwards made a series of experiments with reference to the effect of light on animal life. He found that by excluding the light from tadpoles, development was arrested—they ceased to grow. Professor William A. Hammond, of New York, has repeated the experiments of Edwards, with the same results. Dr. Hammond has also experimented with other animals.

Two kittens, twenty days old, one weighed eighteen ounces, and the other eighteen ounces and a half. The first one was placed in a box to which the light of the sun had free access; the second in a similar box from which the light was excluded. Both were fed alike, and given the same care in all other respects, except light. At the end of the first five days, number one had attained the weight of twenty-two and a half ounces, while number two weighed but twenty and three-quarter ounces. At the end of a second period of five days, number one weighed twenty-four ounces, while number two scarcely weighed twenty-two ounces. The two were now placed together in the box which was exposed to the light, and at the end of the third period of five days each weighed within a fraction of twenty-five ounces. Humbolt ascribes the infrequency of deformities among the native Mexicans, Peruvians, and other native Americans to the fact that they are from childhood subjected to the free influence of solar light upon the whole surface of the body.

All good medical observers have remarked the pale and sickly bodies, and the frequency of deformities among people who live in houses insufficiently lighted, and particularly among persons who work in mines, and persons who live in dark courts and basements into which the sun rarely or never shines. Such persons are extremely subjected to palpitation of the heart, dropsy, and hemorrhages, and when taken sick with any disease they rarely recover.

Dr. Hammond also particulary remarks upon the situation of school-houses, often such as to wholly exclude the sunlight from half of the rooms. And in these, excessively crowded as they often are, the pupils are like the sickly plants—etiolated, weakly, and frequently deformed. No room should be used for a school which does not admit of sunlight at least two hours every day that it shines.[1]

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[1] "Sanitary Influence of Light." The Sanitarian, Vol. I., p. 84.

CHAPTER XII.

FORESTS.

FUNCTIONS OF PLANTS IN DRYING THE SOIL—FOREST AIR ESSENTIALLY MOIST—SPECIAL QUALITIES OF PINE FORESTS—CONSERVATIVE INFLUENCE OF FORESTS IN COLD CLIMATES—EFFECTS OF FORESTS ON TEMPERATURE—RELATIONS OF ELECTRICITY AND OZONE TO FORESTS—THE EUCALYPTUS, ITS HISTORY, CULTIVATION, AND PROPERTIES.

THE influence of forests in producing and modifying the effects of a humid state of the atmosphere is, in some respects, comparable with the sea-coast and the ocean. The great "Dismal" Swamps of Virginia and the Carolinas, for example, are known to be healthy in the interior, even for the white man, while on their borders, or in portions where the trees are felled, they are like the sea-coast—commonly insalubrious.

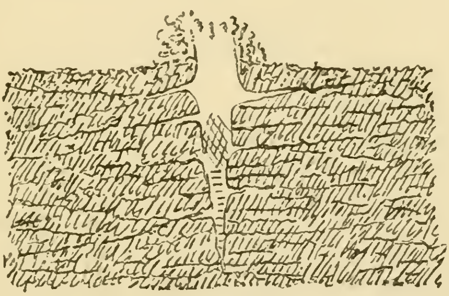
The same conditions obtain in the Mexican Gulf region and on the west coast of Africa. On the borders of the great forests, or wherever they are interspersed with sandy plains or sparse of trees from other causes, fevers prevail; while in the denser regions, and especially where the forest consists of spike-leaved trees, fevers are ordinarily absent. Indeed, the common belief that intervening trees even often afford protection against malarious marshes is founded on observations sufficiently well verified to be accepted as a general truth. And, as truly remarked by Becquerel, more than thirty years ago, "Humid air charged with miasmata, is deprived of them in passing through a forest."[1] Yet forests are in themselves store-houses of moisture everywhere.

That forests are commonly salubrious is probably due to the joint functions of the trees in draining the soil, distilling the moisture, emission of aromatic vapors, particularly of the pitch-pine and eucalyptus, and absorbing the emanations of vegetable putrefaction. And here it may be remarked that while moisture is an indispensable condition of forests, they do not have, as is popularly supposed, much, if indeed any, influence over the rainfall. Those who hold that they do, mistake effect for cause—the rain produces the forest, and not the forest the rain.

Soil drainage is naturally accomplished in forests by the processes of

[1] Becquerel: "Des Climats et de l'Influence qu'exercent les sols boisés et non boisés."

growth and decay of the roots of the saplings and trees. It is particularly manifest in pine forests, proverbial for their salubrity. No boy who has ever engaged in the sports of hare-hunting in a pine thicket, or farmer who has cleared pine lands, that has not acquired some familiarity with stump-holes—the holes left by the decayed tap-roots of the young trees. All forests spring up at first in thickets, and as the young trees enlarge and become crowded for want of room to spread their branches, the "survival of the fittest" soon becomes a condition of their existence. The tender saplings, as they die out and give room, also bequeath benefits to their survivors by establishing a system of drains promotive of their healthy development. This they do by the mode of growth and decay of the roots. The growth of the pine especially affords an admirable illustration.



NATURAL DRAINAGE OF A PINE SAPLING.

The tap-root, penetrating from a few inches to a few feet in depth, according to the size of the sapling or tree at the time of its death, with its numerous radical branches, as they decay, establish a natural system of soil drainage, which may be studied with profit by engineers and agriculturists. This drainage system of pine thickets begins when the trees are quite small.

All observers know that pine thickets are of exceedingly thrifty growth. During the first year, from the time the seeds take root, the trees grow to the height of from twelve to twenty inches; the second year, three times as much—three to four feet; and by the end of the third year the young trees are from eight to ten feet high, and the thicket almost impenetrable, and at about this time the weaklings begin to perish. The sappy roots decay with wonderful rapidity, leaving in their places an inimitable network of soil-drains. The system is by no means confined to pine forests, though it is, perhaps, more clearly manifest in them than in others. No matter what the kind of forest, nor how old the trees, as all trees grow as long as they live, and as young trees are constantly springing up and contending for the mastery, the weakliest of both old and young are as constantly dying out to give place

to the more hardy, and thus this natural system of drainage continues as long as the forest lasts. Moreover, this process of soil-drainage by plants is far from being confined to forest trees; it obtains more or less with all plants. There is probably no region of country in the world where its benefits are more striking than in the growth of the willow on the lower Mississippi.

Immense areas of overflown areas thereabouts, from time to time, are, in an almost incredibly short period of time, covered with impenetrable willow thickets, in active process of transforming swamps into dry and salubrious soil. And although the roots of the willow are without central taps, what they lack in this respect is fully compensated for by the great extent and thick interlacing of the lateral radicals, their wonderful power of absorbing moisture from the soil, and, when the saplings thin out and the roots decay, the otherwise compact soil, by the river deposit, is converted into a loose and fertile surface. And the immensity of the leaf-surface of willow thickets distilling the water absorbed by the roots is beyond calculation.

As an illustration of the extent of foliage expanse, an instance is cited in Gray's First Lessons in Botany and Physiology of an estimate made a few years ago of a single tree—the "Washington Elm"—at Cambridge, Massachusetts, a tree of no extraordinary size, but it was computed to produce a crop of *seven millions* of leaves, exposing a surface of two hundred thousand square feet, or about five acres of foliage.

From this example of the evaporating and radiating surface of foliage, we gain some appreciation of the hygrometric and thermoscopic effect of forests. In the tropics, and in the summer season of temperate climates, the trees impose a complete canopy between the ground and the sky, and the branches frequently interlock, covering many miles of surface. To comprehend the immensity of forest foliage expanse, thus perpetually distilling the moisture absorbed by the roots of plants, is beyond the power of the human mind.

While, therefore, by their myriad leaves, the trees of the forest intercept the moisture of the passing clouds, and the fallen leaves form a spongy surface-soil which absorbs the rains that fall upon it (where there is no declivity for them to run off), to be gradually soaked into the earth, but nevertheless constantly forming a vast reservoir of moisture, it is evident, from what has already been stated, that the means for the purification and disposal of moisture thus accumulated are correspondingly great and perfectly consistent with salutary results.

The conservative influence of the forest on climate is most obvious in cold weather, when the moisture is precipitated in the form of snow, and accumulates, as it frequently does, to a great depth. Sheltered from the winds, the snow itself becomes a protecting cover to the ground which seldom freezes. The snow is not impervious to the sun's rays, and for this reason, the first snow-fall, that which is in immediate

contact with the frozen crust of the earth, if one has already been formed, is soon thawed, and the surface of the ground is subsequently kept below the freezing point throughout the winter. Hence the bottom layer soon begins to melt, and proceeds more or less rapidly, according to the relative temperature of the air and the earth's surface. The resulting water is gradually absorbed and carried off by infiltration with such facility that both the snow and the layer of leaves lying between it and the ground often appear to be quite dry, notwithstanding the under surface of the leaves and the accumulated vegetable mould are in a state of continuous moisture.

Doubtless a small portion of the snow returns to the atmosphere by the process of evaporation, and some runs off into superficial water-courses. But owing to the protection afforded by the shade from the rays of the sun, and the entanglement of the icy surface pierced by the trees and undergrowth, the great body of the snow deposited in forest regions is retained until it there melts.

The snow-water slowly imbibed by the earth, besides promoting the growth of the overshadowing trees, gradually sinks, according to the greater or less permeability of the soil, and proceeds to seek out or to form unseen conduits, which wind their way along into channels and springs, or oozing out at the hillsides, there form rills which, anon, swell into streams and rivers, and descend to the sea whence it came. The roots of the forest trees in all climates usually imbed themselves in the moist soil sufficiently deep to be in a temperature of about the annual mean. In the most important regions of both America and Europe, and especially in those portions which have suffered most from the destruction of the forests, the superficial strata of the earth are colder in winter and warmer in summer than the strata a few inches lower. This shifting temperature of different strata below the surface of the earth approximates to the atmospheric mean of the respective seasons. The trees being conductors of heat, when the earth is colder than the air, convey the heat of the atmosphere *to* the earth, and when the temperature of the earth is higher than that of the air, they transmit the heat in the opposite direction *from* the earth. It follows, then, as conductors of heat, the forests play an important part towards the equalization of the temperature of the earth and the atmosphere.

In temperate latitudes especially the effect of forests on temperature is considerably increased by the nature of the foliage. A large proportion of the trees are of deciduous foliage, and their radiating, as well as their shading surface, is very much greater in summer than in winter.

The temperature of the forest in all climates is higher in winter and lower in summer than that of the open ground. Every one who has visited the forests with any frequency knows that he need go but a short distance within its borders to escape the influence of even a furious wind, and that woodmen engaged in felling trees in the winter rarely

find inconvenience from cold winds, which penetrate but a short distance, even when the trees are devoid of their leaves. As the woods shelter those within from the winds, they in like manner protect the adjacent open country from the blasts which would otherwise sweep over them, and which, by their cold and mechanical force, and by their desiccating influence, prove very injurious to agriculture. Hence the presence of a forest, in its effect on adjacent regions, is often equivalene to a difference of several degrees in the latitude.

It has been remarked by Dr. F. L. Oswald that the "Prince de Ligne, countryman and contemporary of Maria Theresa, wrote an essay 'On the Location of the Earthly Paradise,' and after some reflection on the hygrometric influence of different climates, calls attention to the fact that 'paradise traditions, in locating the garden of Eden, differ only in regard to longitude, but not to latitude. The latitude keeps always near the *snow-boundary*, a line just south of the regions where snow may fall, but will not stay on the ground. It passes through Thibet, Cashmere, Northern Persia, and Asia Minor, and reaches the meridian of Europe near the centre of the Mediterranean.' The nations that 'celebrated the life as a festival' have lived along this line, and we may doubt if in the most favored regions of the New World human industry, with all the aids of modern science, will ever re-unite the opportunities of happiness which Nature once lavished on lands that now entail only misery on their cultivators. All over Spain and Portugal, Southern Italy, Greece, Turkey, Asia Minor, Persia and Western Afghanistan, and throughout Northern Africa, from Morocco to the valley of the Nile, the aridity of the soil makes the struggle for existence so hard that, to the vast majority of the inhabitants, life from a blessing has been converted into a curse. . . . And all this change is due to the insane destruction of the forests."[1]

The effect of forests on the electrical state of the atmosphere, and the generation of ozone, is also, doubtless, a force of great influence adding to the general salubrity, and under some circumstances giving them special potency.

While electricity results from any kind of chemical change or action, of which there is much incessantly going on in the natural relations of the forest to the atmosphere and soil, the condensation of vapor into rain is, perhaps, the most prolific of all sources of electricity. And besides this, which is apparent to all observers, when we consider the invisible, but none the less active processes of absorption and exhalation, the amount of water daily absorbed from the soil by every thrifty tree, and how small a proportion of this fluid consists of matter which enters into new combinations and becomes a part of its solid frame-work, it is evident that the superfluous water is somehow returned to the atmosphere

[1] "Popular Science Monthly," vol. xi., p. 385.

almost as rapidly as it is absorbed. Again when we reflect upon the interposing obstacles to the dew, mists, fogs, and light showers and the redispersing of the water from these sources into invisible vapor to cool the air; and the influence of the same obstacles in heavy rains, serving to break the big drops and scatter them into misty fragments—the multiplication and combination of these influences abundantly account for the electrical state of the atmosphere of the forest.

Moreover, to the same active influences *and* electricity is due the exalted activity of oxygen—the generation of ozone—always active, when present, as a destroyer of organic matter in process of decay, and in this case hastening the return of the emanations of vegetable decay to their original elements—the elements of a pure and vivifying atmosphere. Hence the specially invigorating effect of a forest atmosphere in some states of the human system, and its general salubrity in all.

Sudden accession to the amount of vapor in the atmosphere, especially if associated with a fall of temperature, are well known to have decided effects on the state of the public health; and rheumatic and gouty invalids are proverbial for the certainty with which they foretell a storm by their sensations—due to the decrease of atmospheric pressure.

According to some observations of Dr. Ballard, with reference to seasons in England:

"Both in the colder and warmer seasons of the year, a comparatively dry condition of the atmosphere is more dangerous to the public health than a comparatively moist one."[1]

But these observations of Dr. Ballard seem to have been confined to dense populations—to cities. How far they may be general, however, is suggested by the common salubrity of forests, notwithstanding their dampness.

THE EUCALYPTUS.

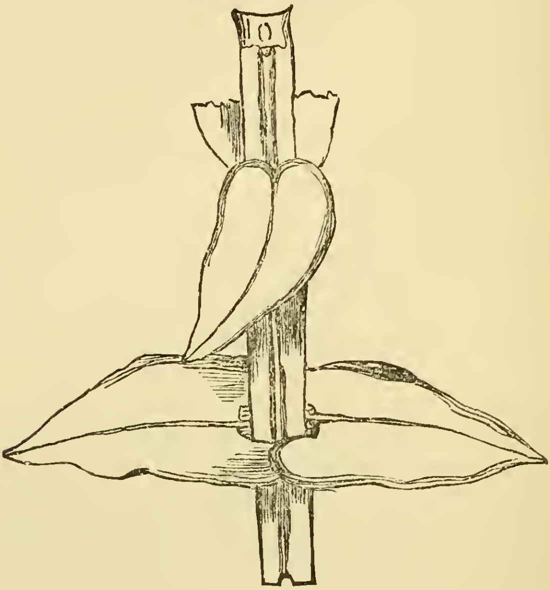
No account of forests would be complete without an account of the prophylactic properties of the eucalyptus. By it, especially, is illustrated the functions of drainage, absorption, and distillation to a degree greatly surpassing that of any other known plant.

The eucalyptus exists in great variety, and there is reasonable hope that its climatological distribution may be greatly extended, although, hitherto, its cultivation has met with but very limited success in climates subject to frost. As just remarked, this tree exists in great variety, yet observation has, until very recently, been chiefly limited to one species, the *E. globulus*. There is good ground for belief that the anti-miasmatic properties, with which this particular species is credited, are at least par-

[1] "On the Influence of some of the more Important Elements of Weather upon the absolute Amount of Sickness." British Medical Journal, June 12th, 1869.

tially, if not indeed equally, possessed by several other species of the same order.

The stem of the young plant is four-sided like the Mint family. The leaves are heart-shaped and sessile. On each side of the square-shaped stem is a depression within which the leaf is attached; the cordate notch at the base of the leaf is so deep that the lobes of one leaf lie upon another, appearing, at first sight, like the upper side of the perfoliate leaves of the honeysuckle. Each pair is set at right angles with those above and



below, and with horizontal plane, the upper surface being exposed to the sun and the under in the shade, and, as to plants generally, the under surface only is supplied with stomata or breathing organs. They are of bright, grassy-green color, thin, soft, and juicy. But ere the plants have attained the age of ten years, a complete transformation of all the stem- and leaf-characteristics sets in, and in the "grown-up" trees they have wholly disappeared.

Instead of a square-sided, greenish, herbaceous-looking stem, we have a huge white-colored trunk, and gnarled branches twisted into wild fantastic shapes. The leaves are no longer amplexicaul, but stand well out from the branch-stems, twisted upon and suspended by long petioles, and instead of being heart-shaped and opposite, they are now scythe-shaped, and the plane of their surfaces wholly changed—their edges turned to the sun and earth—and, most remarkable of all, the stomata, instead of being limited to one surface of the leaf, are now distributed over both surfaces. The color, instead of grass green, has turned to a bluish-green, and gives significance to the name of "blue" gum tree. And

now, too, instead of the thin, soft, and juicy leaf of the young plant, we have a thick, leathery, and dry leaf, but doubly equipped in their power of distilling moisture, both sides of the leaf work equally, and they are o placed that the sun's rays in co-operation with them, penetrating between their vertical surfaces, are scarcely intercepted in the exercise of their fullest force on the surface of the moist ground where these beneficent trees are most wont to flourish.

As seen with its shining white bark in Tasmania and Central Australia, with its white or light-red and dark shadows of curious foliage trembling in the passing breeze, and towering to the height of from three hundred to four hundred feet, it is not unfrequently a beacon to to the thirsty traveller, for it signifies his approach to water, or at least to the bed of a river or lake. Indeed, it usually marks the water courses so well that a distinguished explorer observes "that in travelling along the Darling and the Lachlan, I could with ease trace the general course of the river without approaching the banks until I wished to encamp."[1]

[1] F. V. Muller, "Transactions of the Royal Society of Victoria," part 1, vol. viii.

A nearly allied species, the *amygdalina* growing amidst the deep ravines of Dandemony, in Victoria, is said to measure the enormous height of 480 feet—even outstripping the great California pines—and there is a great number of such trees growing in that region.

In great contrast, a dwarf species, called by the natives *"goborro,"* grows only in places subject to inundation and in swamps, and usually carries markings on its stems, showing the height to which the water has risen. One traveller, Mr. Oxley, remarks that during his journey there was always water to be found where these *goborro* trees grew; and Sir Thomas Mitchell states that "all permanent waters are invariably surrounded by the *"yarra"* (the *globulus,* called *"yarra"* by the natives). The one thrives on the margins of the stream, the lake and the lagoon, and the other in the midst of the marshes and inundations, however long their duration.

Still another species, the *"dumosa,"* grows in sand too barren and too loose for any other production, and but for this growth and prickly grass the sand must have drifted so as to overwhelm the vegetation of adjacent districts, against which nature appears to have curiously provided by the abundant distribution of these two plants, so singularly adapted to such soil. The root of the *"dumosa"* resembles that of a large tree; but instead of a trunk, only a few branches rise above the ground, forming an open kind of bush, often so low that a man on horseback may look over it for miles. The heavy spreading roots, however, of this dwarf tree and the prickly grass together occupy the ground and seem intended to bind down the sands of the vast interior of Australia. Their disproportioned roots also prevent the bushes from growing very close together; and the stems being leafless, except at the top, this kind of eucalyptus is almost proof against the running fires of the bush.

In all, more than twenty species of eucalyptus have been described, possessing a variety of useful properties and purposes.

The groves of the larger species, especially, are delightfully fragrant, filling the air at great distances with the delicate aroma of balm or lemon, and other odors indescribably delicious. All observers agree that in Tasmania, and in those portions of Australia where the eucalypti flourish, miasmatic fevers rarely or never exist.

Yet it seems to have taken the most enlightened nations about thirty years after the coincidence of the existence of the eucalyptus growth and the absence of malarial fevers in Van Diemen's Land was first described to establish their relations.

The eucalyptus was first imported into France by M. Ramel, in 1856, and for anything that appears to the contrary, solely at first as an ornamental tree. The first notable features of it were its extremely rapid growth and powerful influence in drying up marshes, the dispersion of mosquitoes and other insects which infest marshy places. In many

places, in Algeria especially, it was rapidly brought into requisition for the redemption of marshy lands, and for the same purpose it was planted in the valley of the Osheoni, a region of country celebrated alike for its fertility and its insalubrity. And here it seems to have been first observed, within the period of about ten years from the time the plants were first introduced, that, together with the drying up of the marshes, malarial fevers proportionally disappeared. It has since been introduced at Cape Colony, into the French possessions in Africa, into various places in the south of France, Cuba, and various other countries; but in none with decided results as in the famous Campagna of Rome, a place no less famous for its deadly fevers in modern, than for the evidence of its greatness in former times.

The following sketch of the Campagna, and history of the introduction and effects of the eucalyptus there, is by H. N. Draper, F.C.S.[1]

"One lovely morning in last October, we left our hotel hard by the Pantheon, and in a few minutes came to the Tiber. If we except the quaint and bright costumes of many classes of the people, and the ever changing street-scenes of Rome, there is nothing in the drive of very much interest until we reach the river. Here, looking back, we see the noble structure which crowns the Capitoline Hill. The fine building on the farther bank of the river is the Hospital of St. Michele. On this side we are passing the small harbor of the steamboats which ply to Ostia. Presently, the *Marmorata*, or landing place of the beautiful marble of Carrara, is reached. From here a drive of a few minutes brings us to the cypress-covered slope of the Protestant Cemetery, where, in the shadow of the pyramid of Certius, lie the graves of Shelley and Keats. Apart from the interest attached to these two lonely tombs, and the memories aroused by their touching epitaphs, no Englishman can resist this secluded spot, and look without deep feeling upon the last resting-places of his countrymen, who have died so many miles from home and friends. The cemetery is kept in order and neatness, and flowers grow upon nearly all the graves.

"Our route next lay along the base of that remarkable enigma, the *Monte Testaccio,* a hill as high as the London Monument or the Vendôme columns at Paris, made entirely of broken Roman pots and tiles, as old perhaps as the time of Nero! Leaving behind this singular heap of earthenware, we thread long avenues of locust trees, and presently, passing through the gate of St. Paul, reach the magnificent basilica of that name. Nor can I pause here to dwell upon the marvels of this noble temple; or to tell of its glorious aisles and column-supported galleries; of its lake-like marble floor, or of the wealth of malachite, of lapis lazuli, of veræ antique, of alabaster, and of gold, that has been lavished upon the decoration of its shrine. I must stop, however, to note that

[1] From a contribution to Chambers' Journal, for March 26th, 1881.

nowhere has the presence of the dread *malaria* made itself so obvious to myself. We had scarcely entered the church when we became conscious of an odor which recalled at once the retort-house of gas-works, the bilge water on board ship, and the atmosphere of a dissecting room; and we were obliged to make a hasty retreat. There could be little doubt that the gaseous emanations that produced this intolerable odor were equally present in the campagna outside, but that in the church they were pent up and concentrated.

"Even did the space admit, this is not the place to enter into prolonged dissertation on the history or causes of this terrible scourge of the Roman Campagna, the fever producing *malaria.* The name expresses the unquestionable truth that it is a gaseous emanation from the soil; and all that is certainly known about it may be summed up in a very few lines. The vast undulating plain known as the Campagna was ages ago overflowed by the sea, and owes its present aspect to volcanic agency. Of this the whole soil affords ample evidence. Not only are lava, perperino, and the volcanic puzzuolana abundant, but in many places, as in Bracciano and Baccano, are to be seen the remains of ancient craters. When the Campagna was in the earliest phase of its history, it was one fertile garden, interspersed with thriving towns and villages. It was also the theatre of events which resulted in making Rome the mistress of the world. This very supremacy was the final cause of its ruin and of its present desolation. While the land remained in the possession of small holders, every acre was assiduously tilled and drained; but when it passed into the hands of large landed proprietors, who held it from the mere lust of possession, it became uncared for and uncultivated. Filtering into the soil loaded with easily decomposed sulphur compounds, the decomposing vegetable matter finds no exit through the underlying rock. The consequences may be imagined, but to those who have not experienced them, are not easily described. This once fertile land is now a horrid waste, untouched, except at rare intervals, by the hand of the farmer, and untenanted save by the herdsman. Even he, during the months of summer when the malaria is at worst, is compelled, if he will avoid the fever, to go with his flocks to the mountains. It may be mentioned, in passing, that the malaria fever, or 'Roman fever,' as it has been called, has been the subject of recent investigation by Professor Tommasi-Crudelli, of Rome, who attributes it to the presence of an organism, to which the specific name of *Bacillus malariæ* has been given.

"Leaving St. Paul, we pursued for a short time the Ostian road; and at poor *Osteria,* where chestnuts, coarse bread, and wine, were the only obtainable refreshments, our route turned to the left, along a road powdered with the reddish dust of the pozzuolana—the mineral which forms the basis of the original "Roman cement," large masses of which rock form the road-side fences. After a drive of perhaps half an hour, we found ourselves at the Monastery of Tre Fontane (three fountains). The

Abbey of the Tre Fontane comprises within its precincts three churches, of which the earliest dates from the ninth century. One of these, *San Paolo alle Tre Fontane*, gives its name to the monastery. A monk, wearing the brown robe and sandals of the Trappist order, met us at the gate. The contrast now presented between the sterile semi-volcanic country around, and the smiling oasis which faces us, is striking. Here are fields which have borne good grass; some sloping hills covered with vines; and directly in the fore-ground almost a forest of eucalypt trees.

"We have come to learn about the eucalyptus; and our guide takes quite kindly to the rôle of informant. What follows is derived from his *viva voce* teaching, from my own observations on the spot, and from a very interesting pamphlet, printed at Rome in 1879, and entitled 'Culture de l'Eucalyptus aux Trois Fontanes,' by M. Auguste Vallée.

"Before the year 1868, the abbey was entirely deserted. It is true that a haggard-looking monk was to be found there, who acted as cicerone to visitors to the churches; but even he was obliged to sleep each night in Rome. The place obtained so evil reputation that it was locally known as 'The Tomb.' There are now twenty-nine brothers attached to the monastery, all of whom sleep there each night. This remarkable result, though no doubt to a great extent due to the drainage and alteration of the character of the soil by cultivation, is unquestionably mainly owing to the planting of the eucalyptus. It would take long to tell of the heroic perseverance of these monks; of the frequent discouragements; of the labor interrupted by sickness; of the gaps made in the number by the fatal malaria, and the undaunted courage in overcoming obstacles which has culminated in the result now achieved. Let us pass to the consideration of the actual means by which so happy a change in the immediate surroundings has been brought about. At Tre Fontane are cultivated at least eleven varieties of eucalyptus. Some of these, as *E. viminalis* and *E. botryoïdes,* flourish best where the ground is naturally humid; *E. resinifera* and *E. meriadora* love best a dryer soil. The variety *globulus* (blue gum tree) possesses a happy adaptability to nearly any possible condition of growth. At the monastery, as in most elevated parts of the Campagna, the soil is of a volcanic origin, and there is not much even of that, often only eight and rarely more than sixteen inches overlying the compact *tufa*. But with the aid of very simple machinery the Trappists bore into the subsoil, blast it with dynamite, and find, in the admixture of its *débris* with the arable earth, the most suitable soil for the reception of the young plants.

"The seeds are sown in autumn in a mixture of ordinary garden earth, the soil of the country, and a little thoroughly decomposed manure. This is done in wooden boxes, which, with the object of keeping the seeds damp, are lightly covered until germination has taken place. When

the young plants have attained to about two inches, they are transferred to very small flower-pots, where they remain until the time arrives for their final transplantation. The best time for this operation is the spring, because the seedlings have then quite eight months in which to gather strength against the winter cold. One precaution taken in planting is worth notice. Each plant is placed in holes of like depth and diameter. In this way no individual rootlet is more favored than its fellow and, as each absorbs its soil nutriment equally, the regularity of growth and final form of the tree is assured. A space of three feet is left between each seedling; but so rapid is the growth that in the following year it is found necessary to uproot nearly one-half of the plants, which finally find themselves distant from each other about five feet. From this time, much care is required in weeding and particularly in sheltering from the wind, for the stem of the eucalyptus is particularly fragile, and violent storms sometimes rage in the Campagna. The other great enemy of the tree is cold, and this offers an almost insurmountable obstacle to its successful culture in Great Britain. It seems to be well proved that most of the species will survive a winter in which the temperature does not fall below 23° Fahr. How fortunate is the circumstance that the culture of the tree at Rome, may be learned from the fact that the mean lowest temperature registered at the observatory of the Roman College during the years 1863–'74 was 23.48°. Once only in those years a cold of 20° was registered, and even that does not seem to have injured the plants; but when, in 1875, the minimum temperature fell to 16°, the result was a loss in a single night of nearly half the plantation of the year.

"But when, as at Tre Fontane, the conditions of growth are on the whole favorable, the rapidity of that growth approaches the marvellous. The mean height, for example, of three trees, chosen for measurement by M. Vallée in 1879, was twenty-six feet, and the mean circumference twenty-eight inches. These trees had been planted in 1875, or in other words were little more than four years old. Other trees of eight years' growth were fifty feet high and nearly three feet in circumference at their largest part. These figures refer to *eucalyptus globulus*, which certainly grows faster than the other species; and it must be remembered that in warmer climates the growth is even still more rapid. I have seen, for example, trees of *eucalyptus resinifera* at Blidah, in Algeria, which at only five years old were already quite sixty feet high.

"The question of how and why the eucalyptus exercises sanitary changes so important as those which have been effected at this little oasis in the Campagna may be best answered when two remarkable properties which characterize many of the species have been shortly considered. The first of these is the enormous quantity of water which the plant can absorb from the soil. It has been demonstrated that a square metre—which may roughly be taken as equal to a square yard—of the leaves of the

eucalyptus globulus will exhale into the atmosphere during twelve hours four pints of water. Now, as this square metre of leaves—of course, the calculation includes both surfaces—weighs two and three-quarter pounds, it will be easily seen that any given weight of eucalyptus leaves can transfer from the soil to the atmosphere nearly twice that weight of water. M. Vallée does not hesitate to say that under the full breeze and sunshine—which could necessarily form no factor in such accurate experiments as those conducted by him—the evaporation of water would be equal to four or five times the weight of the leaves. One ceases to wonder at these figures, on learning that it has been found possible to count on a square millimetre of the under surface of a single leaf of *eucalyptus globulus* no less than three hundred and fifty *stomata* or breathing-pores. And it now begins to be intelligible that, if such an enormous quantity of water can be transferred from earth to air, it may be possible that an atmosphere, which without such aid would be laden with malarious exhalations, may be rendered pure by this process of leaf-distillation: the putrescible constituents of the stagnant water are absorbed by the roots, and become part of the vegetable tissue of the tree.

"But this is not all. Like those of the pine, the leaves of all species of the eucalyptus secrete large quantities of an aromatic essential oil. It has recently been shown—and the statement has been very impressively put by Mr. Kingzett—that, under the combined action of air and moisture, oils of the turpentine class are rapidly oxidized, and that, as a result of this oxidation, large quantities of peroxide of hydrogen are produced. Now, peroxide of hydrogen is—being itself one of the most potent oxidizers known—a very active disinfectant; and as the leaves of some species of the eucalyptus contain in each hundred pounds from three to six pounds of essential oil, we can hardly avoid the conclusion that the oxygen-carrying property of the oil is an important element in the malaria-destroying power of the genus. Moreover, the oxidation of the oil is attended by the formation of large quantities of substances analogous in their properties to camphor; and the reputation of camphor, as an hygienic agent, seems sufficiently well founded to allow us to admit at least the possibility of these bodies playing some part in so beneficent a scheme.

"As we travelled the coast-line *via* Civita Vecchia to Leghorn, we could not help being struck by the fact that the precincts of all the railway-stations were thickly planted with the eucalyptus. And looking back at not only what has been actually accomplished during the past ten years, but to the important fund of information which has been accumulated, one can only look forward hopefully and with encouragement to the future of the eucalyptus in the Roman Campagna."

In the United States, the cultivation of the eucalyptus, for its prophylactic properties, has attracted but little attention. The tree is said to

be common in Southern California, and the late T. M. Logan, M.D., Secretary of the California State Board of Health, made a special report upon its growth in that State, ten years ago; but since that time there has been little or nothing more written about it.

It is quite clear, from the description of its climatic adaptability and cultivation in the Campagna of Rome and other places abroad, that it might be cultivated to very great advantage in several of the Southern States. A plant of such wonderful qualities and properties, that springs from the seed in five years to the height of forty to sixty feet, and in sixteen years to the height of eighty to one hundred feet, with a trunk seventeen to twenty-four inches in diameter, and possessed, the while, with the power of absorbing water four or five times the weight of its leaves daily, which it digests and eliminates as ethereal vapor, aromatizing the air for great distances around; that a number of such plants possessed of such properties should exercise a powerful influence over the region of their growth is, indeed, nowise surprising; and it is surely worthy of the attention of all persons who reside in regions where it can be utilized.

CHAPTER XIII.

CLIMATOLOGICAL TOPOGRAPHY IN GENERAL.

SIZE, POSITION, AND SHAPE OF MASSES OF LAND—SURFACE CONDITIONS—RELATION TO OCEAN CURRENTS AND WINDS—OUTLINE AND GENERAL CONFIGURATION.

It has already been shown that the proportions of land and water, and the position and shape of sea-coasts, hold important relations with the circulation of the atmosphere and the distribution of heat; that the ocean, traversed in various directions by currents of warm and cold water, exercises a powerful influence over the temperature of the land which borders upon it; and that the temperature of the air, everywhere, greatly depends upon the character of the bottom of the aërial ocean, whether it is land or water; and if the former, on the nature of the surface with regard to vegetation or aridity, plain or variable, mountainous or otherwise; and if the latter, whether it is ocean, lake, or river.

For a clear appreciation of these influences, it is necessary to compare the relations of other quarters of the world with North America in the general distribution of climate.

The relative size, position, and shape of continental masses constitute important agencies in centralizing atmospheric temperature and directing ocean currents in the distributing of heat. These differences account for the different temperatures in the same latitudes of the northern and southern hemispheres, and on the same meridians of the eastern and western continents. They afford abundant reason for the accumulation of heat in low latitudes where the heat transmitted by the sun is great at all times, and for the accumulation of heat over the large areas of Africa and Asia thus favorably situated in the low latitudes, and which, by proximity, greatly add to the heat of Southern Europe. The effect of mass in higher latitudes, where the proportion of radiating or refrigerating time is much greater than that in which the sun's heat is received, is due to the same cause.

The great expansion of the American continent in the higher latitudes exaggerates the difference caused by the diminished mass south. The Arctic and sub-Arctic regions are therefore colder than those of Europe and Asia, though this effect is more decidedly confined to the latitudes in which it originates than the other; the cold at the north

influences lower latitudes less than the heat at the south influences the higher. The refrigeration in the Arctic regions of this continent is excessive in winter because there is no accumulation of heat south to balance it, as the land narrows off to so great an extent. There is no Africa, Arabia, or India to balance our Siberia; and consequently our continent, as a whole, has a lower temperature than the corresponding latitudes of the Eastern hemisphere. While the Eastern hemisphere comprehends a very large area bordering on the tropics, the Western comprehends very little, and as the effect of land areas to increase the temperature by the accumulation of heat, or to diminish it by radiation, depends wholly upon the sun's altitude, the middle latitudes are softened in winter temperature by the mass of land on the south in greater proportion than they are refrigerated by land at the north; hence the mildness of the climate of the south of Europe as compared with the same latitudes in the United States.

Humbolt remarks: "As in the old continent, European civilization has had its principal seat on the western coast, it could not fail to be early remarked that under equal degrees of latitude the opposite eastern litoral region of the United States of North America was several degrees colder in mean annual temperature than Europe; which is, as it were, a western peninsula of Asia, and bears much the same relation to it as Brittany does to the rest of France. The fact, however, escaped notice that these differences decrease from the higher to the lower latitudes, and that they are hardly perceptible below 30°. But the mildness of the winter in New California shows that in reference to their mean annual temperature, the west coasts of America and Europe, under the same parallels, scarcely present any differences." [1]

Blodget observes in regard to this: "For the east coast we have then similar lines and configuration to those of Asia; and near this coast there is the same class of sea currents, to whatever cause these sea currents may be due. Commodore Perry has shown the existence there of a stream of warm water strikingly similar to the Gulf Stream of the Atlantic; and if these have their origin in a confinement of the heated waters of the tropics on that side of the continent, the causes and consequences should be, as they are, similar. Whatever portion of the coast is within the influence of this current in either case is affected similarly, and, in accordance with the rule, the softened climate of Japan and of the islands of the vicinity, and their contrast with the climate in the same latitudes are very noticeable. The great storms at sea off this coast, also appear to be like those of the Gulf Stream and Atlantic coast. Whether the current would cease with a different line of coast in either case we need not inquire in the present purpose, nor whether the hypothesis at some time proposed be true, that the evi-

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[1] "Views of Nature," p. 99.

dences of a high temperature and semi-tropical vegetation in Arctic America prove the existence of a current like the Gulf Stream over the then *submerged* Mississippi plain and eastern part of the continent. With similar lines of configuration on that side of the continent, in each case we find similar physical phenomena in all that may control existing climates.

"With the western side the configuration is not the same, and, as before intimated, the continent is believed to be rendered colder, relatively, by this fact, at least to the degree of the difference of land and water temperatures near the borders of the tropics, which difference may be assigned at nearly 1° of the thermometric mean. In comparison with Europe, there is a further disadvantage of position in the much greater distance of the coast from the warm-water current passing northward on the east coast of each continent. Europe is directly and largely influenced by the Gulf Stream, but the Japanese stream is too far off to be felt directly on the Pacific Coast of America; and it is in truth felt there quite directly in a reverse character, as the answering or cold current—that which in greater part returns west of, or beneath the Atlantic heated stream, but which in the Pacific comes full upon the coast of America in middle latitudes, while the warm waters have been spent in expanding over an immense ocean surface. This result is due to position and exterior configuration, and, in these two cases, in conjunction with the great altitudes of the western borders of this continent, all the differences of temperature between the two divisions of the temperate latitudes may be found. The last cause named is not so general or controlling as the first, because the cold current is a comparatively narrow mass at the point of its rising on the coast, and evidently is not felt north of the 45th parallel. The average reduction due to both causes is less than 2° on the mean temperature.

"The position of the continents relative to the prevalent winds of the temperate latitudes is of great importance, and necessarily a part of the configuration. In referring to it, it becomes necessary to assume what is not universally conceded, namely, a belt of westerly winds as the great characteristic of these latitudes. In proof that such a belt exists, the difference of temperature of the opposite coasts of both seems a conclusive evidence. If no atmospheric circulation modified this distribution, by conveying the heated or refrigerated air in some direction, there is no reason for any such difference as we find to exist. The maximum of continental effect in refrigeration and aridity should be found in the centre of the continent, and its degree should be as great on the west as on the east. But the differences are scarcely less extraordinary at the west of North America as compared with the east—Sitka with Labrador—than in the comparison of England and Kamtschatka, England being directly influenced by the Gulf Stream. Why it is so influenced is seen in this atmospheric circulation

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itself, which clearly carries the air eastward for all those temperate latitudes; the heat and humidity of the masses transferred being gradually exhausted until the maximum of continental effect is thrown nearly to the eastern coasts of both. This very evident fact would be conclusive if the surface wind gave no evidence in conformity, since a superior system, or superior aerial currents would alone be sufficient to produce a marked result. But we have the observed winds of all the middle latitudes to confirm the assumed circulation. Three-fourths of the number and force of all the winds recorded at 35° to 50° N. latitude are from some points into which west enters, and their average resultant, as traversed in an accurate manner, is within two or three points from due west. The greater facts of temperature distribution between the opposite sides of the continent have their full solution here.

"Under this system of atmospheric circulation the altitude of bordering districts becomes more important than before, and it may be said, in brief, that the great altitude of the mountains and plateaux nearly bordering on our Pacific coast develops at once an extreme continental effect, and aids in rendering the continent unduly cool and dry. This is the remaining cause of difference between Europe and America, and in the colder seasons its influence is very decided, as may be seen in a brief reference to the facts of temperature and rain distribution here.

"In the view here taken of the system of atmospheric circulation lying at the base of the climatology of these latitudes, the great altitude of the continental mass near the Pacific by no means alters the course of the circulation, or shuts off the west wind of the upper and more general movement by any impassable wall. These winds are as regular as before, or elsewhere, though they are necessarily cold and somewhat deficient in moisture at that elevation, and therefore lose much of the heat and moisture they have over the ocean surface before reaching the interior. The prevalent winds are west winds, at all points sufficiently elevated to eliminate the local effect, and the course of the clouds above the lower strata is equally regular. In short, there is no evidence that this wall modifies the atmospheric circulation in its more general character, or in that believed to be central at the equator, though local winds and movements of a peculiar character are developed at many points, subordinate to the general one, and the low, warm, humid sea atmosphere which so greatly influences the climate of Europe is almost entirely cut off.

"There is another effect of configuration which may be noticed here. It is the supposed deflection of the northeast trade wind up the Mississippi Valley by the great altitude of the continental mass in Mexico. Whether such a deflection occurs or not it is difficult to say; and altitudes like those of the central regions of Mexico may be found to exert a great influence on the atmospheric movements in low latitudes. It is reasonable to suppose that this normal movement may be checked at that dis-

trict, and that the attraction of the area of rarefying air over these plains, as they become heated in spring and summer, may induce the moderate winds from the south, southwest, and southeast, known to belong to nearly all the Gulf coast and Mississippi Valley during the winter months.

"The vertical configuration of the Mississippi Valley is peculiarly favorable to the relative development of such a result, as it is particularly open and low on the south everywhere. The whole of the immense plain sloping to the Gulf of Mexico perpetuates the conditions first instituted at its southern border, and the prevalent south, southeast, and southwest winds are but the necessary incidents of the high temperature of the plain, in the light aspirate degree in which they blow for the warmer months. They are not identified with a large mass of air, and are almost always crossed above by the clouds borne on the prevalent west winds, which may be set down as well defined at and beyond the thirty-fifth parellel." [1]

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[1] Op. cit., pp. 117-120.

CHAPTER XIV.

CLIMATOLOGICAL TOPOGRAPHY OF THE UNITED STATES.

TABULATED STATISTICS AND METEOROLOGICAL DATA.

RELATIVE PROPORTION OF DEATHS FROM CONSUMPTION AND NERVOUS DISEASES TO DEATHS FROM ALL CAUSES—BAROMETRICAL RECORD—TEMPERATURE RECORD—HUMIDITY RECORD—PRECIPITATION RECORD—ELEVATION ABOVE SEA LEVEL—BAROMETRICAL REDUCTIONS TO SEA LEVEL.

TABLE.

Proportion of Deaths from Consumption to Deaths from all Causes in the United States, Deduced from U. S. Census Report for 1880.

States and Territories.	Total number of deaths from all causes.	Deaths from Consumption.	Percentage from Consumption.	States and Territories.	Total number of deaths from all causes.	Deaths from Consumption.	Percentage from Consumption.
United States	756,893	91,551	12.09	Mississippi	14,683	1,287	8.7
Alabama	17,929	1,729	9.	Missouri	36,615	3,604	9.8
Arizona	291	18	6.9	Montana	336	18	5.3
Arkansas	14,812	955	6.3	Nebraska	5,930	416	7.
California	11,530	1,802	15.5	Nevada	728	61	8.3
Colorado	2,547	210	8.2	New Hampshire	5,584	866	15.5
Connecticut	8,179	1,389	16.	New Jersey	18.474	2,630	14.2
Dakota	1,304	116	8.8	New Mexico	2,436	50	2.1
Delaware	2,212	357	16.1	New York	88,332	12,858	14.5
District of Columbia	4,192	793	18.9	North Carolina	21,547	2,130	9.9
Florida	3,159	263	8.3	Ohio	42,610	5,912	13.8
Georgia	21,549	1,879	8.7	Oregon	1,864	226	12.1
Idaho	323	22	6.8	Pennsylvania	63,881	8,073	12.6
Illinois	45,017	4,653	10.3	Rhode Island	4,702	691	14.8
Indiana	31,213	3,943	12.3	South Carolina	15,728	1,543	9.8
Iowa	19,377	1,925	9.9	Tennessee	25,919	3,767	14.5
Kansas	15,160	1,117	7.3	Texas	24.735	1,622	6.5
Kentucky	33,718	3,733	11.5	Utah	2,314	69	3.
Louisiana	14,514	1,514	10.4	Vermont	4.024	813	20.2
Maine	9,523	1,829	19.2	Virginia	24,681	3,025	12.3
Maryland	16,919	2,381	12.	Washington Ter.	755	100	13.2
Massachusetts	33,149	5,207	15.7	West Virginia	7,518	969	12.9
Michigan	19,743	2,613	13.2	Wisconsin	15,011	1,681	11.2
Minnesota	9,037	848	9.3	Wyoming Territory	189	5	2.6

PROBABLY no country in the world possesses a greater variety of climate than the United States. This is primarily due to the conditions which have already been described; and secondarily to those conditions which will now engage our attention—the variable topography of the country.

As a basis and reference of, and for the description in detail which follows, tabulated statistics are here introduced, constructed out of, or extracted from the material and sources credited.

TABLE.

Proportion of Deaths from Nervous Diseases to Deaths from all Causes in the United States, Deduced from the U. S. Census Report for 1880.

States and Territories.	Total number of deaths from all causes.	Deaths from Nervous Diseases.	Percentage from Nervous Diseases.	States and Territories.	Total number of deaths from all causes.	Deaths from Nervous Diseases.	Percentage from Nervous Diseases.
United States........	756.893	83,670	11.	Mississippi	14,683	1,436	9.7
Alabama	17,929	1,675	9.3	Missouri............	36,615	4,117	11.2
Arizona.............	291	19	6.5	Montana......	336	28	8.3
Arkansas	14,812	1,424	9.6	Nebraska...........	5,930	442	7.4
California...........	11,530	1,306	11.	Nevada.............	728	55	7.5
Colorado......... ...	2,547	182	7.1	New Hampshire....	5,584	751	13.4
Connecticut.........	8.179	1,381	16.8	New Jersey.........	18,474	2,941	15.8
Dakota	1,304	105	8.	New Mexico... ...	2,436	72	2.9
Delaware.	2,212	291	13.1	New York..........	88,332	10,129	11.4
District of Columbia.	4,192	515	12.2	North Carolina.... .	21,547	1.792	8.3
Florida.......... .. .	3,159	358	11.3	Ohio.....	42,610	5,738	13.4
Georgia.........	21,549	1,879	8.7	Oregon.............	1,864	182	9.7
Idaho.......	323	27	8.3	Pennsylvania.... ..	63,881	8,199	12.8
Illinois.............	45,017	5,146	11.1	Rhode Island.......	4,702	575	12.2
Indiana.............	31.213	3,456	11.	South Carolina.....	15,728	1,450	9,2
Iowa	19,377	1,931	9.9	Tennessee..........	25,919	2,368	9.1
Kansas..............	15,160	1,306	8.5	Texas..............	24.735	2,450	9.9
Kentucky...........	33,718	2,612	7.7	Utah...............	2,314	185	7.9
Louisiana...........	14,514	1,761	12.1	Vermont...........	4,024	608	15 1
Maine...	9,523	1,136	11.9	Virginia............	24,681	2,569	13.
Maryland...........	16,919	2,062	12.1	Washington Ter....	755	61	8.
Massachusetts.......	33,149	3,837	11.5	West Virginia......	7,518	742	9.4
Michigan............	19,743	1,902	9.5	Wisconsin..........	15,011	1,698	11.3
Minnesota...........	9,037	760	8.4	Wyoming Territory.	189	11	5.8

The statistics of the hygiene of the United States Army for a series of years, comprehending the reports of the medical officers stationed at the various military posts throughout the country, "Circular No. 8," issued from the Surgeon-General's office May 1st, 1875, shows the following:

Ratio of Deaths from Pulmonary Diseases per Mean Strength U. S. Army.

	Mean Strength.	Discharges per 1,000 for		Deaths per 1,000 from		Loss per 1,000 from	
		Consumption.	Diseases of the Respiratory Organs.	Consumption.	Diseases of the Respiratory Organs.	Consumption.	Diseases of the Respiratory Organs.
U. S. Army, white troops, 1870–'74..	25.989	3.828	1.395	1.462	1.462	5.29	2.867
U. S. Army, colored troops, 1870–'74	2,530	2.962	.296	2.47	3.162	5.432	3.458
Arizona..							
California							
Colorado							
Dakota							
Kansas							
Minnesota							
Montana	564,646	.....	.....	1.735	.953	1.735	.953
Nebraska							
New Mexico							
Oregon							
Texas							
Utah							
Washington							
Wyoming							
United States	5,804,616	.....	.....	2.486	.788	2.486	.788

TABLE.

Ratio of Diseases and Deaths from Consumption to Total Number of Diseases and Deaths from all Causes at Military Posts of the United States Army, 1870–1874. *Abstract of Circular No.* 8.

Military Posts.	Altitude.	Mean annual temperature.	Mean rain-fall.	No. of enlisted men.	No. of cases of disease.	No. of cases of consumption.	Per cent of consumption to all other diseases.	Total deaths.	Deaths from Consumption.	Per cent of deaths from consumption to deaths from all causes.
Northern Coast.		°	in.							
Ft. Columbus, N. Y.	....	51.53	46.69	2,184	4,618	17	.0036	68	6	.0882
Ft. Adams, R. I.	....	47.95	37.84	1,020	1,514	3	.0019	9	1	.1111
Ft. Independence, Mass.	....	46.46	40.78	227	537	7	.0130	1	0	.0000
Ft. Preble, Me. *a*	....	46.10	30.69	170	72	2	.0279	3	0	.0000
Average	....	50.51	39.01	3,601	6,741	29	.0043	81	7	.0864

Military Posts.	Altitude.	Mean annual temperature.	Mean rain-fall.	No. of enlisted men.	No. of cases of disease.	No. of cases of consumption.	Per cent of consumption to all other diseases.	Total deaths.	Deaths from consumption.	Per cent of deaths from consumption to deaths from all causes.
Southern and Gulf Coasts.		°	in.							
Ft. Monroe, Va............	....	58.18	42.16	1,361	1,636	16	.0097	13	3	.2307
Charleston, S. C. *b*	....	..	..	601	903	5	.0055	6	2	.3333
Key West Barracks, Fla. *c.*	....	78.09	44.87	372	875	4	.0045	8	1	.1250
Ft. Brown, Tex............	....	72.41	20.80	606	1,332	4	.0030	9	3	.3333
Average	Sea level.	69.56	35.94	2,940	4,846	29	.0056	36	9	.2500
Northern Interior.	Ft. above sea-level.									
West Point, N. Y *d*..... ..	157	51.24	39.91	1,210	1,627	13	.0080	4	0	.0000
Plattsburgh, N. Y.....	186	43.92	29.86	283	648	4	.0060	0	0	.0000
Ft. Snelling, Minn..........	840	42.93	20.51	434	1,106	3	.0027	3	0	.0000
Omaha Barracks, Neb. *e*...	960	50.91	31.58	1,573	2,307	3	.0013	12	1	.0833
Average....... ...	....	47.25	30.46	3,500	5,688	23	.0040	19	1	.0526
Southern Interior.										
Columbia, S. C. *f*.........	300	64.06	53.01	885	1,722	8	.0046	13	2	.1546
Jackson Barracks, La. *b*....	10	..	..	975	1,999	6	.0030	15	2	.1333
Ringgold, Tex...	521	74.92	14.75	448	711	7	.0098	10	0	.0000
Ft. Leavenworth, Kan. *g*..	?	51.88	57.04	1,492	2,901	6	0020	16	1	.0625
Average...........	....	63.62	41.60	3,800	7,333	27	.0036	54	5	.0925
Interior, 1,000 to 2,500 ft.										
Atlanta, Ga................	1,078	62.60	63.46	1,167	1,719	8	.0046	18	3	.166
Ft. Hays, Kan. *h*..........	1,893	54.25	28.02	814	1,684	9	.0053	12	3	.250
Ft. Sully, Dakota..........	1,660	47.01	16.39	876	1,302	3	.0023	4	1	.2500
Ft. Larned, Kan............	1,932	52.74	16.24	450	864	1	.0011	7	2	.0285
Camp McDowell, Ariz.......	1,800	70.07	11.28	698	957	2	.0020	10	2	.2000
Ft. Sill, Ind. Ter......... ...	1,700	61.08	29.29	1,936	3,058	8	.0026	24	4	.1667
Average............	....	57.95	25.78	59.41	9,584	31	.0032	85	15	.1764
Interior, above 2,500 ft.										
Camp Douglass, Utah.......	4,904	50.46	16.47	1,290	3,676	3	.0008	16	1	.0625
Ft. Stockton, Tex...........	4,950	64.97	12.49	799	628	5	.0078	11	1	.0999
Santa Fe, N. M. *i*..........	6,850	53.63	14.80	200	217	0	.0000	3	1	.3333
Ft. Bridger, Wyoming.....	7,010	38.58	10.28	460	676	5	.0074	3	0	.0000
Ft. Ellis, Montana. *j*.......	5,800	..	..	1,043	703	2	.0028	5	0	.0000
Camp Bidwell, Cal	4,680	49.07	15.05	241	302	2	.0066	6	1	.1666
Average............	....	51.34	13.81	4,033	4,202	17	0040	44	4	.0909

a. Temp. and rain-fall estimated for October, 1873. *b.* Temperature and rain-fall not given. *c.* Rain-fall estimated for Feb., 1871, and June, 1872. *d.* Rain-fall estimated for January, 1874. *e.* Temp. and rain-fall estimated for the year ending June 30th, 1874. *f.* Temp. and rain-fall for last two years only. *g.* Rain-fall estimated for Jan., 1871. *h.* Rain-fall estimated for Jan., Feb., March, 1871. *i.* Temperature and rain-fall for first two years only. *j.* Temperature and rain-fall imperfect and incomplete

MONTHLY AND ANNUAL MEAN ACTUAL BAROMETER (CORRECTED FOR TEMPERATURE AND INSTRUMENTAL ERROR ONLY), DEDUCED FROM OBSERVATIONS TAKEN AT 7 A.M., 3 AND 11 P.M., WASHINGTON MEAN TIME, FROM JULY, 1880, TO JUNE, 1881, INCLUSIVE.

The daily means are obtained by dividing the sum of the 7 A.M., 3 and 11 P.M. observations by three ; the monthly means by dividing the sum of the daily means by the number of days in the month.—(U. S. Signal Service.)

Station.	Elevation of cistern of barometer above mean sea-level, feet.	1830.						1881.						Annual mean.
		July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	
Albany, N. Y.	75	29.877	29.979	29.954	30.015	30.143	29.954	30.070	30.114	29.682	29.797	29.955	29.828	29.947
Alpena, Mich.	609	29.312	29.394	29.342	29.352	29.417	29.324	29.403	29.454	29.201	29.328	29.389	29.303	29.352
Atlanta, Ga.	1,131	28.902	28.903	28.932	28.950	29.009	28.904	28.938	28.934	28.722	28.834	28.896	28.823	28.896
Atlantic City, N. J.	13	29.986	30.069	30.051	30.115	30.241	30.019	30.136	30.173	29.735	29.888	30.050	29.902	30.030
Augusta, Ga.	183	29.858	29.890	29.932	29.952	30.044	29.930	29.990	29.980	29.724	29.828	29.852	29.776	29.896
Baltimore, Md.	45	29.957	30.022	30.022	30.086	30.217	30.028	30.124	30.163	29.743	29.889	30.012	29.879	30.012
Barnegat, N. J.	20	29.961	30.044	30.022	30.086	30.213	29.990	30.107	30.147	29.704	29.862	30.025	29.876	30.003
Bismarck, Dak.	1,704	28.155	28.157	28.146	28.187	28.275	28.286	28.277	28.207	28.206	28.181	28.141	28.067	28.190
Boise City, Idaho	2,768	27.155	27.094	27.250	27.300	27.401	27.153	27.286	27.220	27.222	27.152	27.139	27.071	27.203
Boston, Mass.	142	29.812	29.902	29.862	29.924	30.043	29.797	29.920	29.977	29.540	29.661	29.901	29.738	29.840
Brackettville, Tex.	1,137	28.808	28.811	28.836	28.922	28.964	28.938	28.940	28.856	28.783	28.766	28.731	28.733	28.841
Breckinridge, Minn.	966	28.931	28.954	28.930	28.952	*a*29.086	......	......	......	......	......	......	......	......
Brownsville, Tex.	43	*b*29.928	29.868	29.919	30.009	30.073	30.057	30.082	*c*29.998	29.926	29.899	29.858	29.845	29.955
Buffalo, N. Y.	664	29.258	29.323	29.314	29.336	29.416	29.275	29.367	29.404	29.058	29.219	29.315	29.210	29.291
Burlington, Vt.	268	29.700	29.775	29.753	29.801	29.913	29.744	29.874	29.872	29.448	29.542	29.728	29.588	29.728
Cairo, Ill.	377	29.679	29.668	29.730	29.749	29.883	29.800	29.806	29.742	29.542	29.637	29.639	29.581	29.705
Campo, Cal.	2,527	*d*27.396	*e*27.328	27.360	27.415	27.441	27.438	27.482	27.470	27.425	*f*27.406	27.348	27.358	27.406
Camp Thomas, Ariz.	(*)	*g*27.214	27.168	27.212	27.261	27.272	27.283	27.293	27.236	27.217	27.174	27.099	27.116	27.212
Cape Hatteras, N. C.	8	30.019	30.067	30.062	30.094	*a*30.192	......	......	......	......	......	......	......	......
Cape Henry, Va.	16	29.984	30.042	30.052	30.109	30.234	30.034	30.133	30.160	29.765	29.913	30.034	29.894	30.029
Cape Lookout, N. C.	15	30.010	30.047	30.054	30.082	30.195	*h*30.034	......	......	......	......	......	......	......
Cape May, N. J.	27	29.959	30.036	30.018	30.085	30.214	30.003	30.117	30.157	29.722	*i*29.870	*j*30.018	29.873	30.006
Castroville, Tex.	778	29.200	*b*29.186	29.220	29.307	*f*29.397	*d*29.282	29.336	*k*29.246	29.185	*i*29.182	*e*29.152	29.137	29.234
Cedar Keys, Fla.	22	30.066	29.988	30.040	30.045	30.140	30.094	30.110	30.100	29.986	30.051	29.978	29.982	30.048
Charleston, S. C.	52	29.966	29.997	30.025	30.066	30.151	*e*30.048	30.106	30.108	29.842	29.960	29.986	29.910	30.014
Charlotte, N. C.	838	29.184	29.222	29.250	29.275	29.352	29.199	29.269	29.276	28.984	29.143	29.193	29.097	29.204
Chattanooga, Tenn.	783	29.256	29.262	29.300	29.326	29.398	29.308	29.329	29.327	29.085	29.203	29.239	29.177	29.267
Cheyenne, Wyo.	6,089	24.141	24.116	24.126	24.105	24.004	23.927	23.910	23.919	23.945	23.996	24.049	24.034	24.023
Chicago, Ill.	661	29.281	29.315	29.328	29.340	29.439	29.364	29.391	29.367	29.155	29.291	29.313	29.224	29.317
Chincoteague, Va.	18	29.988	30.055	30.049	30.110	30.233	30.029	30.139	30.168	29.751	29.908	30.041	29.898	30.031
Cincinnati, Ohio	620	29.393	29.410	29.451	29.466	29.573	29.473	29.494	29.480	29.207	29.248	29.389	29.304	29.416
Cleveland, Ohio	690	29.281	29.329	29.337	29.448	29.442	29.321	29.382	29.389	29.088	29.250	29.315	29.211	29.316
Coleman City, Tex.	1,735(?)	*b*28.202	*e*28.204	28.240	28.293	28.345	28.317	28.311	28.243	*i*28.157	*i*28.144	28.140	*l*28.110	28.225

Columbus, Ohio	805	29.178	29.207	29.233	29.248	29.342	29.228	29.264	29.261	28.972	29.125	29.188	29.088	29.194
Concho, Tex	1,888	28.071	28.095	28.126	28.160	28.229	28.184	28.167	28.100	28.040	28.029	28.013	28.002	28.101
Corsicana, Tex	448	29.564	29.551	29.562	29.654	29.744	m29.711	29.706	29.626	29.547	29.526	29.495	29.492	29.598
Champaign, Ill	768	....	....	....	n29.262	29.385	29.277	29.292	29.247	29.032	29.168	29.194	29.115	....
Davenport, Iowa	615	29.334	29.353	29.395	29.396	29.531	29.462	29.478	29.431	29.254	29.364	29.351	29.272	29.385
Dayton, Wash	1,700	....	....	....	....	....	....	o28.410	28.287	28.306	28.274	28.280	28.191	....
Deadwood, Dak	4,630	25.441	25.410	25.424	25.410	25.372	25.279	25.262	25.252	25.285	25.317	25.372	25.320	25.345
Decatur, Tex	1,160(?)	d28.844	k28.840	b28.891	f28.942	j28.991	28.950	e28.929	k28.840	28.781	i28.767	k28.750	28.734	28.855
Delaware Breakwater, Del.	20	29.978	30.043	30.017	30.092	30.222	30.016	30.028	30.162	29.732	29.887	30.031	29.890	30.016
Denison, Tex	767	29.227	29.207	29.253	29.305	29.390	29.349	29.335	29.257	29.179	29.174	29.150	29.138	29.247
Denver, Col	5,294	24.853	24.837	24.878	24.866	24.808	24.710	24.708	24.708	24.717	24.741	24.778	24.733	24.778
Des Moines, Iowa	849	29.111	29.118	29.161	29.165	29.272	e29.244	29.243	29.197	29.057	29.126	29.089	29.007	29.149
Detroit, Mich	661	29.306	29.361	29.364	29.374	29.461	29.347	29.413	29.405	29.118	29.273	29.332	29.235	29.322
Dodge City, Kans	2,512	27.409	27.422	27.429	27.458	27.514	27.442	27.434	27.387	27.327	27.358	27.364	27.290	27.403
Dubuque, Iowa	665	29.272	29.298	29.324	29.318	29.423	29.390	29.407	29.377	29.202	29.297	29.294	29.211	29.318
Duluth, Minn	644	29.268	29.312	29.249	29.267	29.382	29.357	29.416	29.434	29.310	29.315	29.324	29.227	29.322
Eagle Pass, Tex	800	29.143	29.163	29.205	29.300	29.404	29.366	29.375	29.277	29.196	29.169	29.130	29.122	29.237
Eagle Rock, Idaho	4,781	....	....	....	....	....	p25.220	25.268	25.253	25.263	25.223	25.216	25.188	....
Eastport, Me	61	29.845	29.925	29.909	29.953	30.041	29.796	29.898	29.985	29.605	29.630	29.995	29.784	29.864
El Paso, Tex	3,770	26.221	26.219	26.257	26.283	26.261	26.261	26.250	26.207	26.186	26.172	26.137	26.151	26.217
Erie, Pa	681	29.267	29.305	29.303	29.318	29.408	29.282	29.357	29.381	29.065	29.232	29.310	29.202	29.286
Escanaba, Mich	612	29.304	29.366	29.312	29.314	29.394	29.339	29.417	29.447	29.256	29.340	29.365	29.278	29.344
Florence, Ariz	1,553	28.351	28.311	28.366	28.451	28.499	28.501	28.535	28.444	28.424	28.396	28.295	28.305	28.406
Fort Apache, Ariz	5,004	25.055	25.035	25.070	25.078	25.024	25.026	25.010	25.004	24.984	24.998	24.959	25.006	25.021
Fort Assinniboine, Mont.	2,650	....	q27.170	27.165	27.206	27.294	27.223	27.221	27.123	27.107	27.127	(r)	(r)	....
Fort Bennett, Dak	1,440	....	....	s28.454	28.411	28.539	28.525	28.515	f28.448	28.420	i28.417	28.346	28.258	....
Fort Benton, Mont	2,700	27.010	26.993	27.205	b27.254	27.344	27.254	27.267	27.158	27.144	t........	u27.161	27.078	....
Fort Buford, Dak	1,876	27.915	27.961	27.986	28.029	28.101	28.132	28.112	28.020	28.005	27.922	27.962	27.876	28.002
Fort Custer, Mont	3,100(?)	26.840	26.796	26.856	26.889	26.957	26.865	26.869	26.803	26.790	26.802	26.804	26.725	26.833
Fort Davis, Tex	4,918	25.260	k25.248	v........	v........	w25.238	25.197	25.157	25.156	25.137	25.155	25.143	25.171	....
Fort Elliott, Tex	3,000	27.003	27.282	27.316	27.326	27.352	27.276	27.280	c27.247	x27.225	27.198	27.200	27.155	27.238
Fort Gibson, Ind. T	510(?)	29.466	29.445	29.495	29.543	29.659	29.599	29.592	29.519	29.404	29.408	29.379	29.345	29.488
Fort Grant, Ariz	4,737	25.198	25.184	25.249	25.254	25.219	25.206	25.183	25.169	25.167	25.177	25.167	25.221	25.199
Fort Griffin, Tex	1,243	28.727	28.744	28.782	28.842	28.887	28.846	28.795	28.680	28.605	28.586	28.568	28.617	28.723
Fort Keogh, Mont	2,413	27.252	27.388	27.492	27.524	27.612	27.595	27.558	27.481	27.460	27.444	27.439	27.349	27.466
Fort McKavett, Tex	1,217	27.758	27.758	27.796	27.826	27.851	27.830	27.821	27.748	27.696	j27.700	27.684	27.689	27.763
Fort Missoula, Mont.	3,375(?)	26.744	26.692	26.744	26.814	26.924	26.693	26.769	26.709	26.734	26.699	26.699	26.625	26.737
Fort St. Michael's, Alaska.	....	29.847	29.738	29.582	28.825	29.846	29.870	29.843	30.024	29.803	29.919	29.852	29.818	29.830
Fort Shaw, Mont	3,470(?)	26.267	26.248	26.382	26.430	26.483	26.361	26.383	26.293	26.316	26.337	26.356	26.287	26.345
Fort Sill, Ind. T	1,190	28.788	28.775	28.820	28.865	28.941	28.876	28.864	28.798	28.728	28.716	28.699	28.656	28.794
Fort Stevenson, Dak	1,734	e28.114	i28.142	28.110	e28.149	28.228	28.242	28.238	28.185	28.145	j28.141	c28.094	28.018	28.150
Fort Macon, N. C	11	....	....	....	....	....	....	y30.125	30.151	29.813	29.959	30.034	29.922	....
Fredericksburgh, Tex	1,742	28.296	d28.304	28.277	j28.357	i28.393	j28.373	28.345	28.296	28.244	j28.231	28.206	28.224	28.295

* Not determined.
a Station closed November 30, 1880.
b 29 days only.
c 26 days only.
d 23 days only.
e 30 days only.
f 24 days only.
g 21 days only.
h Observations discontinued December 31, 1880.
i 27 days only.
j 28 days only.
k 25 days only.
l Station closed June 27, 1881.
m Office and records burned Dec. 23, 1880; no observations taken Dec. 23, 24 and 25.
n Observations commenced Oct. 13, 1880.
o Barometer readings commenced Jan. 1, 1881.
p Observations commenced Dec. 3, 1880.
q No mail reports received prior to August 1, 1880.
r Record incomplete; observer sick.
s Observations commenced Sept. 27, 1880.
t Data incomplete owing to sickness of observer.
u From 20th to 31st only.
v Barometer unserviceable.
w 17 days only.
x 18 days only.
y Observations commenced Jan. 3, 1881.

MONTHLY AND ANNUAL MEAN ACTUAL BAROMETER, JULY, 1880, TO JUNE, 1881, INCLUSIVE.—CONTINUED.

Station.	Elevation of cistern of barometer above mean sea-level, feet.	1880. July.	1880. August.	1880. September.	1880. October.	1880. November.	1880. December.	1881. January.	1881. February.	1881. March.	1881. April.	1881. May.	1881. June.	Annual mean.
Galveston, Tex.	40	29.984	29.941	29.968	30.040	30.095	30.095	30.096	30.026	29.958	29.966	29.924	29.931	30.002
Grand Haven, Mich.	620	29.320	29.368	29.368	29.365	29.444	29.368	29.424	29.415	29.193	29.338	29.364	29.271	29.353
Hatteras, N. C.	20	.....	.....	.....	.....	.....	a30.029	30.112	30.141	29.786	29 933	30.029	29.928	.....
Helena, Mont.	4,262	25.861	25.827	25.867	25.893	25.945	25.782	25.809	25.743	25.769	25.745	25.775	25.717	25.811
Henrietta, Tex.	915	.....	.....	.....	.....	b29.198	29.136	29.115	29.043	c28.942	d28.932	e28.935	28.883	.....
Indianapolis, Ind.	753	29.222	29.239	29.276	29.283	29.329	29.302	29.305	29.275	29.031	29.178	29.211	29.126	29.231
Indianola, Tex.	26	29.996	29.948	29.973	30.070	30.132	30.128	30.135	30.030	29.957	29.964	29.931	29.935	30.017
Jacksborough, Tex.	1,133	.....	f28.846	28.937	e28.975	29.018	28.973	28.957	28.881	28.806	28.792	g28.777	28.749	.....
Jacksonville, Fla.	43	30.038	29.989	30.031	30.044	30.135	30.075	30.113	30.101	29.920	30.000	29.968	29.947	30.080
Keokuk, Iowa	618	29.332	29.336	29.304	29.402	29.521	29.461	29.474	29.415	29.242	29 343	29.325	29.244	29.374
Key West, Fla.	27	30 058	29.972	29.994	29.990	30.076	h30.076	30.075	30.077	30.010	30.055	29.939	29.987	30.026
Kittyhawk, N. C.	22	30.012	30.048	30.062	30.112	30.211	30.037	30.132	30.164	29.798	29.944	30.066	29.933	30.043
Knoxville, Tenn.	980	29.066	29.074	29.113	29.125	29.196	29.097	29.121	29.102	28.883	29.002	i29.045	28.990	29.068
La Crosse, Wis	708	29 210	29.250	29.253	29.256	29.360	29.335	29.353	29.340	29.178	29.247	29.223	29.126	29.261
La Mesilla, N. M.	4,124	26 088	26.092	26 133	26.168	26.135	26.136	26.123	26.076	26.061	26.047	26.010	26.019	26.091
Laredo, Tex.	401	29.493	29.490	29.535	29.630	29.704	29.675	g29.695	29.597	29.518	29.485	29.446	29.439	29.559
Leavenworth, Kans.	842	29.135	29.123	29.181	29.205	29.320	29.268	29.271	29.205	29.070	29.125	29.079	29.002	29.165
Lewiston, Idaho	800	29.169	29.122	29.232	29.324	29.517	29.179	29.361	29.227	29.240	29.173	29.177	29.079	29.233
Little Rock, Ark.	298	29.703	29.687	29.744	29.781	29.897	29.841	29.837	29.766	29.627	29.666	29.653	29.617	29.735
Los Angelos, Cal	350	29 631	29.547	29.596	29.661	29.722	29.702	29.754	29.711	29.664	29.642	29.574	29.565	29.647
Louisville, Ky.	530	29.457	29.464	29.510	29.523	29.635	29.542	29.553	29.530	29.282	29.411	29.439	29.367	29.476
Lynchburgh, Va.	652	29.344	29.400	29.413	29 449	29.544	29.363	29.446	29.471	29.116	29.262	29.374	29.256	29.370
Madison, Wis.	949	28.981	29.012	29.013	29.011	29.083	29.036	29.062	29.047	28.872	28.986	28.997	28.912	29.001
Marquette, Mich	673	29.253	29.314	29.230	29.237	29.308	29.256	29.344	29.397	29.219	29.277	29.309	29.228	29.281
Mason, Tex.	1,620	g28.363	i28.371	28.383	28.446	h28.482	28.464	28.438	28.387	i28.318	d28.324	28.299	28.302	28.381
Memphis, Tenn.	321	29.729	29.706	29.754	29.787	29.891	29.829	29.830	29.762	29.604	i29.675	29.672	29.632	29.739
Milwaukee, Wis.	697	29.233	29.278	29.279	29.264	29.368	29.298	29.348	29.338	29.137	29 261	29.279	29.193	29.273
Mobile, Ala.	69	30.031	h29.955	29 994	30.025	j30.188	30.079	30.078	30.024	29.910	29.976	29.932	29.912	30 009
Montgomery, Ala.	219	29.833	29.801	29.853	29.883	29.975	29.920	29.932	29.902	29 737	29.810	29 789	29.754	29.849
Moorhead, Minn	923	.....	.....	.....	.....	.....	.....	k29.140	29 090	29.040	29.016	28.969	28.881	.....
Morgantown, W. Va.	963	29.029	29.085	29.109	29.105	29.187	29.052	29.100	29.123	28.798	28.951	29.043	28.937	29.043
Mount Washington, N. H.	6,286	23.874	23.931	23.839	23.719	23.586	23.345	23 392	23.499	23.267	23.367	23.838	23.707	23.614
Nashville, Tenn.	507	29.523	29.516	29.571	29.585	29.690	29.607	29.614	29.577	29.370	29.473	29.491	29.431	29.537
New Haven, Conn.	106	29.863	29.961	29.914	29.978	30.103	29.855	29.993	30.041	29.596	29.736	29.928	29.779	29.895
New London, Conn.	47	29.930	30.023	29.987	30.054	30.169	29.912	30.053	30.121	29.659	29.806	30.024	29.859	29.966
New Orleans, La	52	30.005	g29.945	29.984	30.022	30.103	30.088	30.083	30.027	29.939	29.983	29.931	29.920	30.002
Newport, R. I.	34	29.923	30.021	29.977	30.043	30.162	29.901	30.026	30.090	29.639	29 771	30.007	29.844	29.950
N. Y. City, N. Y.	164	29.821	29.904	29.880	29.939	30.060	29.837	29.949	30.002	29.567	29.709	29.880	29.737	29.857

Norfolk, Va........	30	29.951	30.009	30.019	30.068	30.181	30.002	30.100	30.137	29.732	29.884	30.006	29.891	29.998
North Platte, Nebr... ...	2,841	27.100	27.087	27.125	27.137	27.179	27.114	27.110	27.067	27.027	27.065	27.067	26.978	27.088
New Shoreham, R. I	27	....	....	l30.000	30.084	30.184	29.921	30.075	30.118	29.677	29.807	30.029	29.883	....
Olympia, Wash.......	36	30.054	30.001	30.062	30.110	30.237	29.791	30.052	29.914	29.998	29.974	30.013	29.919	30.010
Omaha, Nebr.............	1,113	28.849	28.851	28.895	28.913	29.016	28.979	28.973	28.913	28.824	28.870	28.824	28.728	28.886
Oswego, N. Y.	304	29.653	29.733	29.697	29.744	29.830	29.664	29.776	29.818	29.437	29.568	29.692	29.583	29.683
Pembina, Dak...........	791	29.052	29.077	m.......	....	....	....	....	....	....	....	....	....	....
Pensacola, Fla.....	30	30.046	29.978	30.037	30.063	30.153	30.127	30.134	30.089	29.972	30.025	29.975	29.955	30.046
Philadelphia, Pa.........	52	29.944	30.022	30.010	30.070	30.200	29.993	30.101	30.138	29.701	29.845	29.995	29.860	29.990
Phœnix, Ariz....	1,068	28.743	28.673	28.727	28.818	28.893	28.887	28.936	28.862	28.838	28.771	28.673	28.670	28.791
Pike's Peak, Colo....	14,134	18.031	18.010	17.955	17.811	17.496	17.539	17.439	17.506	17.543	17.733	17.840	17.974	17.739
Pilot Point, Tex.	800	f29.249	i29.221	29.263	h29.336	h29.403	g29.364	29.330	29.277	29.223	n........	....	....	....
Pioche, Nev..........	6,220	24.092	24.069	24.114	24.133	24.072	23.997	24.041	24.031	24.005	24.009	23.981	23.995	24.045
Pittsburgh, Pa...........	762	29.200	29.215	29.265	29.281	29.371	29.228	29.288	29.318	28.978	29.130	29.219	29.125	29.221
Port Eads, La.	7	....	....	....	....	....	....	....	....	....	o30.054	29.993	29.990	....
Port Huron, Mich........	633	29.295	29.354	29.352	29.369	29.448	29.330	29.408	29.421	29.131	29.297	29.365	29.265	29.236
Portland, Me...	45	29.885	29.971	29.937	29.994	30.109	29.875	29.989	30.051	29.634	29.885	29.999	29.819	29.887
Portland, Oreg..	67	30.015	29.960	30.027	30.099	30.235	29.825	30.068	29.962	30.018	29.981	30.007	29.925	30.010
Prescott, Ariz...	5,300	24.810	24.786	24.814	24.828	24.774	24.759	24.758	24.757	24.728	24.747	24.709	24.754	24.769
Punta Rassa, Fla.........	13	30.056	29.967	30.000	30.004	30.097	30.078	30.086	30.084	29.989	30.043	29.939	29.979	30.027
Red Bluff, Cal......... ...	324	29.508	p29.452	29.560	29.673	29.828	29.643	29.767	29.758	29.701	29.617	29.552	29.525	29.632
Rio Grande City, Tex	205	29.765	29.743	29.773	29.881	29.952	29.893	29.953	c29.851	29.787	29.746	29.717	29.707	29.814
Rochester, N. Y...	589	29.336	29.405	29.387	29.413	29.508	29.356	29.454	29.496	29.135	29.281	29.396	29.289	29.371
Roseburgh, Oreg.........	537	29.521	29.471	29.516	29.603	29.722	29.339	29.559	29.507	29.543	29.493	29.501	29.450	29.513
Sacramento, Cal..	70	29.809	29.772	29.846	29.949	30.079	29.965	30.075	30.070	29.998	29.927	29.853	29.840	29.932
Salt Lake City, Utah......	4,348	25.624	25.594	25.685	25.741	25.759	25.624	25.681	25.657	25.646	25.605	25.570	25.543	25.644
San Antonio, Tex.... ..	676	29.313	29.299	29.324	29.406	29.466	29.451	29.457	29.366	29.291	29.283	29.242	29.248	29.329
San Diego, Cal.....	67	29.935	29.847	29.890	29.953	30.017	30.012	30.070	30.039	29.970	29.904	29.839	29.835	29.943
Sandusky, Ohio.....	639	29.325	29.368	29.379	29.392	29.488	29.376	29.429	29.426	29.141	29.303	29.359	29.256	29.353
Sandy Hook, N. J.	28	29.945	30.027	30.005	30.086	30.206	29.982	30.093	30.143	29.703	29.853	30.022	29.881	29.995
San Francisco, Cal......	60	29.899	29.847	29.908	29.982	30.084	29.962	30.071	30.087	30.026	29.968	29.912	29.905	29.971
Santa Fé, N. M.......	7,046	23.355	23.353	23.344	23.337	23.220	23.212	23.179	23.183	23.170	23.239	23.261	23.306	23.263
Savannah, Ga............	87	29.958	29.969	30.005	30.024	30.111	30.022	30.072	30.070	29.832	29.938	29.945	29.886	29.986
Shreveport, La...........	227	29.794	29.785	29.807	29.864	29.951	29.916	29.907	29.828	29.745	29.753	29.731	29.729	29.817
Silver City, N. M	5,796	24.321	24.311	24.268	24.106	24.025	24.116	24.242	24.238	24.208	24.233	24.211	24.273	24.213
Smithville, N. C...........	34	30.023	30.060	30.074	30.098	30.192	30.065	30.133	30.154	29.833	29.975	30.031	29.930	30.047
Socorro, N. M.	4,565	25.432	25.442	25.480	25.443	25.452	25.432	25.393	25.382	25.356	25.359	q25.327	....	....
Springfield, Ill.	644	29.355	29.353	29.392	29.411	29.523	29.451	29.464	29.410	29.214	29.334	29.334	29.259	29.375
Springfield, Mass...	120	29.843	29.935	29.901	29.965	30.088	29.866	29.982	30.030	29.589	29.715	29.911	29.766	29.883
Spokane Falls, Wash......	1,910	....	....	....	....	....	....	....	r27.976	28.003	27.954	27.979	27.896	....
Saint Louis Mo.	568	29.440	29.439	29.493	29.516	29.636	29.560	29.570	29.505	29.312	29.421	29.417	29.345	29.471
Saint Paul, Minn.........	811	29.092	29.110	29.088	29.092	29.215	29.205	29.215	29.213	29.098	29.126	29.117	29.024	29.133
Saint Vincent, Minn.....	804	....	....	l29.008	29.074	29.205	29.247	29.271	29.240	29.197	29.133	29.088	29.009	....
Stockton, Tex.....	3,050	26.963	26.965	27.009	27.041	27.048	27.022	27.010	c26.949	26.920	26.916	26.884	26.887	26.968
Thatcher's Island, Mass...	48	29.922	30.010	29.971	30.067	30.154	29.898	30.016	30.083	29.637	29.758	30.012	29.841	29.947

a Observations commenced Dec. 1, 1880.
b Prior records incomplete.
c 27 days only.
d 23 days only.
e 25 days only.
f 24 days only.
g 30 days only.
h 28 days only.
i 29 days only.
j 9 days only; office and records destroyed by fire November 17, 1880.
k Observations commenced January 1, 1881.
l Observations commenced Sept. 1, 1880.
m Station closed September 3, 1880.
n Station closed April 1, 1881.
o Observations commenced April 10, 1881.
p August 16 to 31, only.
q Station closed May 23, 1881.
r Observations commenced Feb. 1, 1881.

MONTHLY AND ANNUAL MEAN ACTUAL BAROMETER, JULY 1880, TO JUNE, 1881, INCLUSIVE.—*Continued.*

Station.	Elevation of cistern of barometer above mean sea-level, feet.	1880.						1881.						Annual mean.
		July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	
Toledo, Ohio	651	29.306	29.351	29.362	29.373	29.465	29.357	29.407	29.404	29.131	29.287	29.341	29.238	29.335
Tucson, Ariz	2,404	27.474	27.451	27.500	27.557	27.580	27.595	27.585	27.535	27.522	27.491	27.410	27.427	27.511
Umatilla, Oreg	384	29.635	29.591	29.703	29.795	30.007	29.696	29.898	29.741	29.724	29.674	29.682	29.576	29.727
Uvalde, Tex	891	29.055	*a*29.043	*b*29.080	*a*29.156	29.219	29.189	29.185	29.094	29.006	*a*28.984	*c*28.957	28.953	29.077
Vicksburgh, Miss	244	29.817	29.773	29.824	29.865	29.951	29.916	29.909	29.843	29.732	29.775	29.740	29.742	29.824
Virginia City, Mont	5,810	24.329	24.278	24.331	24.355	*d*24.361	....	....	....	....	....	....	....	....
Visalia, Cal	348	29.455	29.421	29.495	29.613	29.746	29.686	29.771	29.755	29.666	29.590	29.509	29.496	29.600
Washington, D. C	105	29.894	29.960	29.967	30.020	30.143	29.961	30.057	30.082	29.685	29.829	29.944	29.814	29.946
Wilmington, N. C	52	29.949	29.989	30.006	30.036	30.132	29.997	30.094	30.107	29.788	29.928	29.986	29.886	29.991
Winnemucca, Nev	4,327	25.637	25.590	25.684	25.753	25.781	*e*25.750	25.674	25.647	25.636	25.593	25.577	25.519	25.653
Wood's Holl, Mass	35	29.900	29.974	29.971	30.058	30.159	29.895	30.019	30.086	29.630	29.779	30.014	29.847	29.943
Yankton, Dak	1,228	28.684	28.687	28.723	28.749	28.857	28.851	28.825	28.768	28.715	28.734	29.677	29.587	28.738
Yuma, Ariz	141	29.649	29.602	29.674	29.787	29.920	29.892	29.954	29.867	29.819	29.746	29.648	29.624	29.765

a 28 days only.
b 26 days only.
c 30 days only.
d Station removed to Eagle Rock, Idaho, on Nov. 19, 1880.
e 3 days only; office and records destroyed by fire Dec. 4, 1880.

MONTHLY AND ANNUAL MEAN TEMPERATURE, FROM OBSERVATIONS TAKEN AT 7 A.M., 2 AND 9 P.M. (LOCAL TIME)—JULY, 1880, TO JUNE, 1881, INCLUSIVE.

The daily means are obtained by dividing the sum of the 7 A.M., 2 P.M., and twice the 9 P.M. observations by four; the monthly means by dividing the sum of the daily means by the number of days in the month.—(U. S. Signal Service.)

Station.	Elevation of thermometer above ground.	1880.						1881.						Annual mean.
		July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	
	Feet.													
Albany, N. Y.	51	75.3	71.2	65.5	51.8	38.1	25.1	20.2	27.2	36.9	46.9	65.6	65.4	49.1
Alpena, Mich.	54	65.7	65.2	57.6	45.0	26.8	19.7	14.0	15.9	26.3	34.3	54.0	56.3	40.1
Atlanta, Ga.	78	79.7	76.5	69.4	61.0	48.1	42.6	40.8	46.8	49.3	59.5	71.1	78.6	60.3
Atlantic City, N. J.	10	72.1	71.7	67.9	56.1	41.8	29.2	27.7	30.3	38.4	44.7	57.1	64.7	50.2
Augusta, Ga.	18	82.2	80.1	74.0	64.0	51.1	45.2	42.5	50.8	53.0	62.2	75.1	81.7	63.5
Baltimore, Md.	33	77.6	74.8	68.4	56.0	42.1	31.6	30.8	34.8	42.0	52.0	67.9	71.2	54.1
Barnegat, N. J.	6	74.4	70.6	66.1	54.7	40.2	27.9	26.7	29.4	37.5	43.3	55.9	63.2	49.2
Bismarck, Dak.	16	69.5	66.6	55.4	42.3	19.7	3.6	—1.3	9.6	23.7	37.9	60.8	66.3	37.8
Boise City, Idaho	19	75.0	71.9	61.3	51.3	32.2	35.4	31.6	39.2	45.4	54.8	60.9	67.1	52.2
Boston, Mass.	156	71.1	68.9	64.1	50.8	37.5	26.2	22.4	27.9	36.6	43.4	55.2	60.6	47.1
Brackettville, Tex.	6	81.8	77.5	75.6	*a*68.4	*b*42.8	*c*55.6	....	*d*58.6	*b*63.9	....	....	....	....
Breckenridge, Minn.	6	69.7	64.8	54.1	42.2	*e*17.8	....	....	....	....	....	....	....	....
Buffalo, N. Y.	72	70.8	69.2	62.9	49.1	32.6	22.4	18.8	21.8	29.5	36.8	57.0	59.8	44.2
Burlington, Vt.	55	71.7	68.4	62.9	48.7	33.8	20.4	14.1	22.2	33.0	41.2	59.6	61.6	44.8
Cairo, Ill.	44	79.5	79.3	67.5	58.3	37.7	33.0	29.9	38.3	46.0	56.7	72.6	77.9	56.4
Cape Hatteras, N. C.	7	79.1	78.9	70.1	62.7	*e*55.9	....	....	....	....	....	....	....	....
Cape Henry, Va.	16	78.4	76.4	72.1	62.7	49.2	37.6	35.4	38.5	44.7	52.0	65.5	72.9	57.1
Cape Lookout, N. C.	18	80.9	79.1	74.4	65.1	53.5	*f*43.0	....	....	....	....	....	....	....
Cedar Keys, Fla.	20	82.6	80.4	78.7	70.6	63.1	54.9	54.8	58.3	58.8	66.2	76.7	82.4	69.0
Champaign, Ill.	....	....	....	....	*g*45.9	29.5	22.1	19.5	26.4	33.6	45.9	68.3	69.9	....
Charleston, S. C.	40	83.4	81.4	75.8	65.9	53.5	*h*48.6	47.0	52.3	54.6	60.3	73.1	81.8	64.8
Chattanooga, Tenn.	43	77.0	77.0	67.6	59.6	45.3	37.7	37.6	44.4	47.2	57.9	71.4	77.0	58.3
Charlotte, N. C.	35	78.9	76.3	69.7	59.2	45.5	38.4	37.2	43.6	47.5	55.8	70.9	78.7	58.5
Cheyenne, Wyo.	15	66.8	64.8	56.9	42.8	20.2	27.9	23.9	28.8	33.4	46.3	54.3	67.7	44.5
Chicago, Ill.	69	72.7	72.9	63.1	51.3	31.6	23.2	20.0	25.1	32.4	41.7	60.7	73.2	46.5
Chincoteague, Va.	29	74.7	72.7	68.7	59.4	44.1	32.0	30.7	32.8	40.3	45.7	57.9	67.1	52.2
Cincinnati, Ohio	68	77.1	76.8	67.6	56.3	38.3	31.2	30.6	36.5	42.1	51.2	71.6	74.0	54.4
Cleveland, Ohio	78	71.1	70.9	63.7	50.7	31.6	22.8	20.5	25.3	31.8	40.2	62.3	64.3	46.3
Columbus, Ohio	52	75.4	74.7	65.5	52.0	33.7	25.1	25.0	29.5	37.4	47.6	68.2	70.5	50.4
Corsicana, Tex.	19	82.8	82.4	74.8	63.6	45.9	*i*47.4	40.2	49.5	58.4	68.4	76.2	86.2	64.6
Davenport, Iowa	46	75.4	75.1	63.5	51.4	31.0	22.2	14.2	20.1	29.2	45.3	69.6	70.3	47.3
Deadwood, Dak.	16	66.7	64.7	55.4	42.5	20.1	17.8	15.9	24.1	32.0	41.0	54.2	63.5	40.5

MONTHLY AND ANNUAL MEAN TEMPERATURE, JULY, 1880, TO JUNE, 1881, INCLUSIVE.—CONTINUED.

Station.	Elevation of thermometer above ground.	1880. July.	1880. August.	1880. September.	1880. October.	1880. November.	1880. December.	1881. January.	1881. February.	1881. March.	1881. April.	1881. May.	1881. June.	Annual mean.
	Feet.													
Delaware Breakwater, Del	13	73.6	72.4	68.7	58.8	44.0	31.8	29.5	32.5	39.1	45.8	59.2	66.2	51.8
Denison, Tex	17	79.7	80.0	73.1	61.6	41.3	41.1	33.7	43.6	53.2	64.6	73.7	84.4	60.8
Denver, Col	73	71.3	69.7	61.7	47.3	21.7	30.2	26.0	29.6	37.8	53.5	60.1	73.5	48.6
Des Moines, Iowa	35	71.4	73.1	62.2	49.2	28.2	*h*20.1	14.4	20.7	29.1	44.2	67.4	71.3	46.2
Detroit, Mich	61	70.8	69.3	61.6	48.1	30.1	22.2	17.7	26.5	34.2	44.9	64.7	65.3	46.3
Dodge City, Kans	15	76.4	74.8	65.8	51.6	26.2	24.9	20.1	26.6	39.9	54.0	64.4	78.5	50.3
Dubuque, Iowa	32	71.2	72.8	61.2	48.7	27.8	19.1	13.1	20.3	31.2	45.0	68.7	68.9	45.9
Duluth, Minn	19	65.0	64.0	54.9	43.3	19.9	12.9	5.5	15.7	28.2	38.1	51.1	56.8	38.0
Eagle Rock, Idaho	12	...	...	...	...	...	*j*23.8	18.0	26.2	36.5	48.4	55.9	63.6	...
Eastport, Me	32	61.8	60.7	57.2	48.0	33.9	24.4	18.1	25.2	33.4	38.1	47.1	52.4	41.7
El Paso, Tex	17	...	...	...	...	...	...	*k*40.3	51.3	*l*55.3	...	...	...	...
Erie, Pa	32	72.7	70.8	63.0	51.0	31.4	25.3	23.0	25.4	32.3	40.5	60.5	61.2	46.7
Escanaba, Mich	25	65.8	65.2	57.4	44.0	23.5	17.2	7.6	13.2	24.0	32.6	54.5	59.0	38.7
Fort Apache, Ariz	7	...	...	...	...	...	...	*k*33.0	40.6	43.0	57.3	63.5	74.0	...
Fort Gibson, Ind. T	19	79.0	79.1	71.0	58.0	36.5	35.5	27.5	36.7	47.9	61.2	71.6	81.9	57.2
Fort Macon, N. C	8	...	...	...	...	...	...	*m*41.9	44.7	49.4	54.0	68.5	75.4	...
Galveston, Tex	36	83.1	82.6	78.0	69.6	54.1	53.5	47.2	54.8	61.2	68.1	77.5	85.0	67.9
Grand Haven, Mich	23	69.9	68.7	60.9	49.2	32.3	25.3	19.7	23.3	30.9	40.6	62.4	63.0	45.5
Hatteras, N. C	6	...	...	...	...	...	*n*41.9	40.0	41.4	47.7	52.6	67.0	74.0	...
Indianapolis, Ind	52	76.6	76.2	65.1	53.3	31.7	24.3	24.2	30.3	37.3	48.0	71.3	73.4	51.0
Indianola, Tex	29	82.7	81.9	79.9	69.3	52.3	53.9	45.4	55.3	63.8	69.8	77.7	85.0	68.1
Jacksonville, Fla	37	82.6	81.2	76.9	69.0	61.5	54.9	53.0	58.0	60.0	67.4	75.8	83.2	68.6
Keokuk, Iowa	47	78.8	78.5	66.3	52.5	31.6	24.6	19.1	25.2	34.0	47.5	70.8	73.0	50.1
Key West, Fla	43	85.5	83.3	83.1	79.2	78.3	*o*69.9	72.3	70.9	70.2	74.6	80.2	84.7	77.7
Kittyhawk, N. C	4	79.1	76.4	72.4	62.4	51.8	38.5	36.8	39.5	44.8	50.9	63.7	72.7	57.4
Knoxville, Tenn	72	75.2	75.9	67.0	58.5	42.6	34.4	35.5	41.8	44.0	54.6	*p*70.6	71.0	56.2
La Crosse, Wis	40	73.0	71.1	60.7	48.5	25.5	15.8	9.6	18.9	30.8	43.5	68.2	69.3	44.6
La Mesilla, N. M	17	*q*78.7	...	...	...	...	...	...	...	...	...	...	...	...
Leavenworth, Kans	34	78.2	77.6	65.6	52.7	31.9	25.8	21.1	25.5	36.8	50.8	70.1	77.6	51.1
Little Rock, Ark	26	78.8	77.4	69.0	60.9	41.8	40.8	36.1	44.8	51.9	62.7	72.7	81.7	59.9
Los Angeles, Cal	37	63.5	66.1	63.7	61.6	54.8	55.0	51.7	57.5	56.1	61.2	62.6	65.3	59.9
Louisville, Ky	89	77.8	77.9	66.9	56.2	37.5	30.5	29.8	36.5	41.7	52.4	72.2	74.8	54.5
Lynchburgh, Va	30	78.4	76.3	67.9	57.1	42.1	31.1	34.0	38.8	43.9	54.4	70.6	76.0	56.1
Madison, Wis	33	71.9	71.0	60.6	48.5	26.8	17.0	12.6	18.5	28.5	40.9	66.2	66.4	44.0
Marquette, Mich	36	64.4	62.3	55.9	44.0	24.7	19.3	10.1	14.3	24.8	35.2	53.3	55.1	38.6
Memphis, Tenn	53	79.2	78.7	68.6	59.9	39.9	37.3	34.0	43.1	50.5	*p*60.0	74.1	81.5	58.9
Milwaukee, Wis	105	68.9	69.6	61.1	48.4	27.7	19.6	16.6	23.0	30.1	40.8	58.3	70.4	43.7
Mobile, Ala	64	80.0	*o*80.3	75.2	66.7	*r*52.3	49.2	47.9	53.7	57.0	65.6	76.9	83.0	65.6

Montgomery, Ala	34	81.9	80.5	73.6	65.6	51.7	46.9	45.2	51.1	51.3	64.4	76.2	82.9	64.5
Moorhead, Minn	23	....	....	....	....	....	....	s— 2.6	6 8	19.3	34.2	60.7	65.8	....
Morgantown, W. Va	10	71.8	71.4	63.5	53.7	40.1	31.1	32.2	31.9	41.7	49.4	66.0	68.5	52.0
Mount Washington, N. H.	28	47.6	47.0	41.5	30.0	14.2	7.8	2.4	7.2	14.7	16.1	39.0	38 8	25 5
Nashville, Tenn	34	78.4	79.4	68.2	59.9	41.2	35.9	34.9	41.9	46.9	57.8	73.9	78.7	58.1
New Haven, Conn	112	73.5	70.1	64.3	52.0	40.0	27.8	21.7	26.9	36.1	44.1	58.5	62.5	48.1
New London, Conn	29	71.7	69.5	64.2	52.2	39.5	28.2	24.7	29.1	37.5	44.1	56.7	61.8	48.3
New Orleans, La	45	81.7	t81.3	76.8	68.0	56.4	53.0	50.4	56.3	59.9	67.2	77.0	84.8	67.7
Newport, R. I.	19	71.5	69.2	64.3	53.5	41.1	29.7	26.5	29.7	37.5	42.7	54.0	61.2	48.4
N. Y. City, N. Y	148	73.5	71.9	65.7	54.0	40.1	27.7	26.0	29.8	37.1	46.1	60.4	64.2	49.7
New Shoreham, R. I	8	....	....	u64.8	51.5	43.0	31.9	28.8	31.6	37.0	42.5	53.0	60.3	....
Norfolk, Va	20	80.2	76.8	71.3	60.6	47.0	36.2	34.5	39.6	45.6	52.5	67.1	74 4	57.1
North Platte, Nebr	19	73.2	72.5	61.2	47.8	23.7	18.0	13.5	21.7	34.3	48.3	62.2	71.9	45.7
Olympia, Wash	23	62.3	60.8	54.5	49.3	v39.2	39 8	38.8	43.8	46.6	50.9	53.0	58.0	49.7
Omaha, Nebr	59	77.7	75.7	63.6	49.4	26.7	18.4	11.8	18.6	28.1	45.1	68.4	75.9	46.2
Oswego, N. Y	35	71.1	69.0	63.6	50.7	36.8	25.6	21.1	25.2	33.7	40.8	58 4	58.5	46.6
Pembina, Dak	6	65.5	w62.3	....	....	....	....	....	....	....	....	....	....	....
Pensacola, Fla	20	81.0	80.7	76 0	67.5	56.5	51.5	49.5	55.2	57.9	64.8	76 3	82.4	66.6
Philadelphia, Pa	99	75.6	72.8	67.7	55.1	40.5	28.6	25.9	30.7	38.8	48.7	64.1	67 4	51 3
Pike's Peak, Colo	5	38.7	37.4	30.9	18.3	0.5	6.7	Zero.	5.3	5.0	18.7	25.6	40.2	18 9
Pioche, Nev	5	73 5	72.3	65.1	51.0	32 0	35.1	29.8	37.3	39.4	54.6	60.6	70.2	51.7
Pittsburgh, Pa	88	73.4	73.7	65.8	53.4	35.9	26.8	28.2	30 1	37.1	47.4	66.7	68.7	50 6
Port Huron, Mich	80	68.8	67.8	60.3	47.9	28.9	21.8	16.4	21.9	29 0	37.2	56.2	58 0	42.9
Portland, Me	28	70.5	68.1	62.4	50.5	37.8	27.8	22.4	28.6	38.1	43.9	54.8	60.5	47.1
Portland, Oreg	45	66.1	63.8	59.8	52.7	42.2	39.7	39.0	45.5	49.2	55.1	58.1	60 8	52.7
Portsmouth, N. C	8	x79.3	y77.6	z73.6	A66.3	B50.4	C41.4	x39.1	42.8	49.6	53.4	68.2	75.4	59.8
Prescott, Ariz	10	72.6	71.4	61.4	52.3	36.3	37.8	34.7	40.8	40.9	56.8	62.2	71.3	53.5
Punta Rassa, Fla	14	81.8	80.4	80.3	75.1	73.2	63.2	64.8	65.5	65.4	70.0	76.5	82.1	73 2
Red Bluff, Cal	21	85.4	D78.8	75.2	65.5	49.8	49.1	49.4	52.9	55.8	64 2	70.5	74 6	64 3
Rochester, N. Y	100	71.3	69.3	63.2	49.4	33.7	23.6	20.7	24.0	32 0	41 8	62.1	61.4	46.0
Roseburgh, Oreg	20	68.8	65.5	61.7	51.4	39.2	45.6	42.8	47.4	49.0	55 7	57.9	60.2	53 8
Sacramento, Cal	38	72.9	71.3	68.9	62.7	49.6	50.0	49.2	53.6	56.0	62.0	66.7	68.0	60 9
Salt Lake City, Utah	52	75.3	73.5	64.1	51.5	30.3	34.3	32.1	38.2	41.9	54.5	61 5	71.6	52 4
San Antonio, Tex	17	83.0	79.6	76.6	65.4	48.8	50 7	43.8	54.0	63.4	69.4	76.4	86.2	66.4
San Diego, Cal	19	63.2	65.6	62 8	60.9	55.6	55.4	52.4	54.9	54.2	60 7	62.4	64 2	59 4
Sandusky, Ohio	51	72.9	72.5	64.2	51.3	32.9	24.8	23.0	27 0	33.3	43 2	64 3	66.8	48 0
Sandy Hook, N. J	15	74.4	71.6	67.6	56.2	43.1	29.6	26.3	29 2	37.4	45.7	60 5	65 2	50 6
San Francisco, Cal	48	57.7	58.2	58.1	58 9	54.1	53.2	53.8	55.0	54 0	57.1	56 8	57 7	56 2
Santa Fé, N. M	21	67.3	64.9	57 7	46.3	29.4	29.9	24.0	33.0	37 6	52.6	59 0	71.4	47 9
Savannah, Ga	41	83.1	81.2	75.1	65.7	56.1	50.5	48.5	53 8	56 7	63 3	74 2	82 6	65 9
Shreveport, La	33	80.6	81.2	73.1	63.5	46.2	46.6	41.2	48.9	56 1	67.6	75 6	85.3	63.8
Smithville, N. C	18	82.2	80.4	74 5	64 9	53.0	44.8	43.6	47.4	51 5	56 8	70 2	78.5	62 3
Springfield, Ill	39	77.4	77.2	64.6	53 6	32.7	26.2	22.4	29.5	36 2	48 7	70 3	72.2	50.9
Saint Michaels, Alaska	....	52.6	52.3	41.2	28.3	24.4	11.3	17.6	1 2	3 3	23 8	31 9	46.6	27 9
Springfield, Mass	54	73.3	69.8	64.4	50 5	37.6	26.3	20.9	26 8	36.8	46 1	61.8	64.3	48.2
Saint Louis, Mo	104	77.8	78.4	66.6	54.9	32.1	27.3	22.0	30.3	38.9	51.4	72 5	75.5	52.2
Saint Paul, Minn	32	71.6	69.5	58.9	45.7	22.6	13.6	7.9	17.2	30.7	44 0	64.5	67.9	42.8
Sitka, Alaska	64	....	....	....	....	....	....	....	....	....	E42.5	45.4	51.2	....
Saint Vincent, Minn	9	....	....	K51.8	40.1	15.7	1.9	— 5.6	5 8	19.6	31 8	58.7	62 6	....
Socorro, N. Mex	5	....	....	....	....	....	....	F28.6	42.7	G43.2	....	....	....	....
Thatcher's Island, Mass	7	66.9	65.6	61.4	50.2	38.6	27.9	24.3	28.4	37.5	41.9	52.7	58.9	46.2

MONTHLY AND ANNUAL MEAN TEMPERATURE, JULY, 1880, TO JUNE, 1881, INCLUSIVE.—CONTINUED.

Station.	Elevation of thermometer above ground.	1880.						1881.						Annual mean.
		July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	
	Feet.													
Toledo, Ohio	64	73.8	72.2	64.4	51.7	34.0	25.5	22.8	26.9	35.0	45.2	66.3	67.1	48.7
Umatilla, Oreg	7	73.5	70.2	63.9	53.3	35.5	29.6	25.3	34.6	48.9	56.3	60.5	66.1	51.5
Vicksburgh, Miss	32	80.7	80.1	71.9	63.7	47.7	47.0	43.2	50.3	56.2	66.9	76.8	84.6	64.1
Virginia City, Mont	24	62.7	61.3	53.5	41.4	*H*22.3	....	....	....	....	....	....	....	....
Visalia, Cal	22	80.8	77.8	73.8	61.2	46.7	49.9	48.1	53.9	55.7	63 2	70.6	74.1	63.0
Washington, D. C	44	77.2	75.1	68.1	55.5	40.7	29.6	28.2	33.2	40.7	50 8	67.9	70.9	53.2
Wilmington, N. C	28	79.4	77.4	73.0	63.4	51.7	43.3	43.1	49.1	52.1	57.8	70.7	78.4	61.6
Winnemucca, Nev	7	75.1	70.3	62.8	48.9	30.3	*I*39.9	34.9	39.9	41.7	54.2	59.0	66.8	52.0
Wood's Holl, Mass	6	70.2	68.4	64.3	54.4	42.3	30.9	27.2	30.1	37.5	42.2	53.7	59.9	48.4
Yankton, Dak	20	76.2	74.2	62.8	47.4	23.9	14.6	6.9	14.6	23.4	39.5	66.8	72.7	43 6
Yuma, Ariz	5	....	....	....	....	....	....	....	*J*61.4	63.5	73.5	79.4	86.6	....

a Local observations discontinued Oct. 13, 1880.
b For 15 days only.
c Local observations discontinued Dec. 21, 1880.
d For 9 days only.
e Observations discontinued November 30, 1880.
f Observations discontinued December 31, 1880.
g Observations commenced October 13, 1880.
h For 30 days only.
i Office burned Dec. 23, 1880; no observations taken Dec. 23, 24, and 25.
j Observations commenced December 3, 1880.
k Local observations commenced January 1, 1881.
l Local observations discontinued March 31, 1881.
m Observations commenced January 3, 1881.
n Observations commenced December 1, 1880.
o For 28 days only.
p For 29 days only.
q Local observations discontinued July 31, 1880.
r For 9 days only; office destroyed by fire on November 17, 1880.
s Observations commenced January 1, 1881.
t For 30 days only.
u Observations commenced September 1, 1880.
v For 29 days only.
w Station closed September 3, 1880.
x For 25 days only.
y For 26 days only.
z For 24 days only.
A For 18 days only.
B For 21 days only.
C For 23 days only.
D August 16 to 31 only.
E Observations commenced April 1, 1881.
F Local observations commenced January 1, 1881.
G Local observations discontinued March 19, 1881.
H Station removed to Eagle Rock, Idaho, on November 19, 1880.
I For 3 days only; office and records destroyed by fire; observations recommenced December 28, 1880.
J Local observations commenced Feb. 1, 1881.
K Observations commenced September 4, 1880.

MONTHLY AND ANNUAL MEAN RELATIVE HUMIDITY, FROM OBSERVATIONS TAKEN AT 7 A.M., 2 AND 9 P.M. (LOCAL TIME)—JULY, 1880, TO JUNE, 1881, INCLUSIVE.

The daily means are obtained by dividing the sum of the 7 A.M., 2 and 9 P.M. observations by three; the monthly means by dividing the sum of the daily means by the number of days in the month.—(U. S. Signal Service.)

Station.	1880. July.	August.	September.	October.	November.	December.	1881. January.	February.	March.	April.	May.	June.	Annual mean.
Albany, N. Y.	59.4	63.1	67.8	65.4	67.8	74.8	70.1	69.7	69.0	54.1	62.9	62.8	65.6
Alpena, Mich.	75.3	71.3	74.7	73.5	80.2	80.7	75.2	77.4	81.0	68.9	74.4	69.3	75.2
Atlanta, Ga.	62.9	73.3	73.6	66.9	65.1	67.7	71.7	58.5	53.8	56.8	61.8	60.3	64.4
Atlantic City, N. J.	82.0	83.9	78.5	75.6	74.3	76.6	76.8	83.8	74.6	73.6	85.2	79.8	78.7
Augusta, Ga.	65.3	71.4	68.6	74.4	80.3	74.2	76.8	65.5	60.2	60.7	58.8	60.7	68.1
Baltimore, Md.	64.1	70.6	66.1	66.8	66.1	69.2	71.6	66.7	63.2	58.9	64.3	68.1	66.3
Barnegat, N. J.	79.8	81.2	78.0	74.9	73.8	78.6	78.5	78.0	75.1	73.3	86.5	80.8	78.2
Bismarck, Dak.	59.9	63.2	65.8	63.6	78.7	89.4	92.4	86.8	82.2	70.8	56.7	65.4	72.9
Boise City, Idaho	33.7	38.2	38.6	44.9	59.3	75.5	73.0	73.6	65.2	55.8	46.3	43.6	54.0
Boston, Mass.	70.6	70.9	69.7	66.2	63.9	68.9	65.7	71.4	77.0	56.7	74.2	69.3	68.7
Brackettville, Tex.	67.3	74.6	74.9	a67.2	b74.3	c74.3	...	d54.3	b51.5	...	...	...	...
Breckenridge, Minn.	69.4	73.4	70.0	70.4	77.8	(e)	...	...	...	...	...	...	...
Buffalo, N. Y.	67.6	69.3	68.8	69.8	75.1	80.9	79.9	76.4	80.8	70.7	71.3	73.1	73.6
Burlington, Vt.	61.9	62.7	68.6	67.5	70.4	77.1	70.2	73.3	70.8	55.3	70.6	63.7	67.7
Cairo, Ill.	69.3	70.6	73.5	71.8	71.8	75.4	76.2	72.2	62.5	63.3	71.0	71.7	70.8
Cape Hatteras, N. C.	80.3	81.7	77.0	74.8	e79.2	...	...	...	...	...	...	...	...
Cape Henry, Va.	72.8	76.2	71.0	65.4	71.5	69.4	74.3	73.7	66.6	66.9	75.0	72.1	71.2
Cape Lookout, N. C.	74.8	78.3	74.3	74.1	80.8	f78.2	...	...	...	...	...	...	...
Cedar Keys, Fla.	72.7	76.9	75.0	75.0	83.4	78.8	81.0	75.2	66.8	69.8	69.0	69.8	74.4
Champaign, Ill.	...	...	...	g65.3	64.0	70.3	66.2	70.3	72.1	67.7	65.3	76.7	...
Charleston, S. C.	70.7	72.8	71.5	80.2	77.3	h71.7	77.6	66.2	62.6	66.9	71.9	67.5	71.4
Charlotte, N. C.	66.7	74.4	68.7	62.5	70.5	70.6	72.4	63.4	58.5	60.0	59.2	55.2	65.2
Chattanooga, Tenn.	71.7	75.4	76.9	73.5	67.3	72.0	73.9	64.2	59.8	60.6	66.7	70.1	69.3
Cheyenne, Wyo.	43.9	47.0	38.6	45.0	56.1	49.1	57.5	50.4	52.9	51.2	52.8	33.0	48.1
Chicago, Ill.	72.2	70.6	66.9	64.9	65.7	71.9	68.6	72.1	75.3	65.1	64.8	73.2	69.3
Chincoteague, Va.	84.2	84.7	79.5	76.4	79.1	80.9	84.1	79.7	75.4	77.9	89.9	81.5	81.1
Cincinnati, Ohio	63.5	66.7	63.4	63.4	67.9	70.1	69.2	67.8	65.3	62.8	58.8	65.9	65.4
Cleveland, Ohio	70.0	71.8	67.2	67.5	75.9	83.1	82.3	77.8	83.5	74.3	68.9	71.8	74.5
Columbus, Ohio	59.9	63.2	64.0	65.6	68.3	73.9	75.3	72.3	70.6	62.7	60.1	62.4	66.5
Corsicana, Tex.	63.9	61.0	69.9	71.9	63.8	i62.0	63.9	62.1	51.3	53.9	68.4	57.5	62.5

a Local observations discontinued October 13, 1880.
b For 15 days only.
c Local observations discontinued Dec. 21, 1880.
d For 9 days only.
e Station closed November 30, 1880.
f Observations discontinued Dec. 31, 1880.
g Observations commenced October 13, 1880.
h For 30 days only.
i Office burned Dec. 23; no observations taken Dec. 23, 24, and 25.

MONTHLY AND ANNUAL MEAN RELATIVE HUMIDITY, JULY, 1880, TO JUNE 1881, INCLUSIVE.—CONTINUED.

Station.	1880.						1881.						Annual mean.
	July.	August.	September.	October.	November.	December.	January.	February.	March	April.	May.	June.	
Davenport, Iowa	68.0	67.3	67.0	62.0	62.9	70.9	72.5	77.6	75.1	68.3	57.3	69.1	68.2
Deadwood, Dak	53.8	57.4	50.6	52.7	60.8	62.9	65.5	66.1	63.9	61.6	60.1	56.8	59.3
Delaware Breakwater, Del	79.6	83.4	75.8	69.2	75.8	78.3	80.9	78.3	77.2	75.0	84.1	79.7	78.1
Denison, Tex	73.2	68.6	72.1	65.7	71.8	75.1	76.7	72.2	61.3	59.0	75.6	64.4	69.6
Denver, Colo	47.0	47.2	43.9	55.9	64.3	62.3	58.5	56.0	56.2	45.2	52.2	31.3	51.7
Des Moines, Iowa	69.1	70.3	69.5	65.4	66.6	*a*72.1	71.2	77.5	74.6	72.3	69.0	75.7	71.1
Detroit, Mich	70.8	77.3	72.6	73.8	71.4	76.1	77.2	78.4	74.7	61.7	62.3	65.6	71.8
Dodge City, Kans	60.7	58.9	55.7	56.5	60.7	63.6	58.8	65.7	55.6	52.1	75.8	51.8	59.7
Dubuque, Iowa	66.2	69.8	70.7	65.3	69.1	74.7	76.3	74.2	70.3	63.2	59.2	70.7	69.1
Duluth, Minn	69.0	73.8	67.1	74.0	85.7	87.8	79.8	79.4	73.9	69.6	74.0	73.9	75.7
Eagle Rock, Idaho	......	......	......	......	......	*b*77.6	77.7	78.5	63.1	50.0	39.2	37.4	......
Eastport, Me	79.0	78.1	79.7	75.5	67.8	71.7	67.9	70 5	70.4	61.8	76.9	74.2	72.8
El Paso, Tex	......	......	......	......	......	......	*c*43.6	32.8	*d*22.7	......	......	......	......
Erie, Pa	62.7	67.6	68.3	67.8	72.4	80.7	83.4	78.5	81.3	71.0	71.5	76.8	73.5
Escanaba, Mich	73.6	72.8	69.3	76.4	77.8	82.7	79.3	78.9	78.3	68.8	71.4	70.6	75.0
Fort Apache, Ariz	......	......	......	......	......	......	*c*41.5	43.7	49.4	40.8	27.2	16.1	......
Fort Gibson, Ind. T	66.1	65.3	61.6	62.9	68.0	65.6	70.0	70.2	56.7	55.6	77.8	68.1	65.7
Fort Macon, N. C	......	......	......	......	......	......	*e*83.1	78.5	72.0	77.0	79.8	82.8	......
Galveston, Tex	72.2	72.2	79.4	70 3	81.5	80.1	79.7	79.2	69.9	75.0	75.2	68.8	75.3
Grand Haven, Mich	76.8	78.1	73.8	72.9	76.8	82.5	81.1	83.1	81.2	72.4	65.1	71.6	76.3
Hatteras, N. C.	......	......	......	......	......	*f*79.8	84.5	81.4	74.9	79.4	80 3	82.2	......
Indianapolis, Ind	67.0	67.6	62.2	65.0	67.6	71.8	73.6	73.8	71.1	64.0	55.4	66.3	67.1
Indianola, Tex	75.8	76.8	77.2	71.2	81.3	80.5	79.5	78.6	70.8	75.1	76.6	68.9	76.0
Jacksonville, Fla	67.5	71.9	73.0	73.2	77.7	64.0	73.4	62.7	54.7	59.0	68.5	64.2	67.5
Keokuk, Iowa	62.3	61.6	64.3	62.9	66.1	72.6	72.0	74.4	71.7	68.8	62.3	70.5	67.5
Key West, Fla	67.5	73.0	73.6	73.6	76.9	*g*75.9	80.7	72.5	69.0	68.3	70.7	71.6	72.8
Kittyhawk, N. C	75.7	80.2	76.3	73.8	77.1	74.7	81.3	81.1	68.2	72.7	81.1	77.2	76.6
Knoxville, Tenn	73.9	74.1	73.6	70.3	71.9	74.7	79.5	65.8	64.6	63.0	*h*61.1	71.9	70.4
La Crosse, Wis	68.6	69.1	67.7	65.3	73.1	75.5	75.3	72.4	69.8	61.3	58.9	66.7	68.6
La Mesilla, N. Mex	*i*48.2	......	......	......	......	......	......	......	......	......	......	......	......
Leavenworth, Kans	61.6	62.2	67.0	62.2	67.0	69.7	70.6	74.8	65.2	62.3	68.8	66.5	66.5
Little Rock, Ark	75.1	78.6	80.1	72.6	75.7	74.4	81.8	73.5	59.0	65.0	79.1	71.8	73.9
Los Angeles, Cal	73.4	71.9	71.3	62.5	55.1	71.6	62.9	62.1	64.2	71.2	69.1	68.4	67.0
Louisville, Ky	63.3	69.0	70.4	69.5	66.6	69.9	76.4	71.4	66.3	64.2	62.8	68.0	68.1
Lynchburgh, Va	64.5	70.0	67.0	61.7	67.5	67.4	71.7	66.4	55.9	54.9	57.9	59.9	63.7
Madison, Wis	71.6	74.1	70.9	66.8	72.0	74.7	73.9	76.3	74.5	71.4	67.8	74.8	72.4
Marquette, Mich	66.9	70.8	65.5	70.0	68.6	72.8	68.4	66.2	73.5	58.0	66.6	68.6	68.0

Memphis, Tenn	71.8	72.6	77.3	78.1	79.4	79.6	77.7	71.5	57.4	h61.1	66.4	66.6	71.9
Milwaukee, Wis	75.6	74.7	68.1	67.8	73.4	78.0	78.1	82.2	79.1	68.3	69.3	72.6	73.0
Mobile, Ala	76.7	g79.8	79.5	77.7	j85.7	73.6	77.7	69.4	59.5	68.1	66.8	71.4	73.8
Montgomery, Ala	65.1	69.7	70.6	68.9	69.6	70.6	75.7	62.0	57.2	59.6	58.8	60.1	65.7
Moorhead, Minn	......	......	......	......	......	......	k68.7	74.9	73.7	72.0	67.2	71.4	......
Morgantown, W. Va	75.8	78.5	77.0	69.8	63.6	65.3	73.4	66.3	63.6	65.5	69.2	74.2	70.2
Mount Washington, N. H	81.9	80.3	86.6	80.7	88.6	78.9	74.2	78.9	86.3	79.6	82.1	78.3	81.4
Nashville, Tenn	67.8	66.4	72.0	70.7	71.7	73.9	78.0	66.1	61.2	63.7	63.6	63.3	68.2
New Haven, Conn	73.5	76.8	78.8	73.8	64.9	70.9	66.9	70.2	68.2	56.9	74.9	69.6	70.4
New London, Conn	80.9	79.1	78.2	74.5	69.9	72.5	69.8	72.5	74.5	64.4	80.6	78.3	74.6
New Orleans, La	73.0	l73.5	76.2	73.3	76.0	70.5	73.3	71.0	59.9	68.0	69.4	65.5	70.8
Newport, R. I	76.2	78.8	79.7	72.4	72.2	77.8	74.6	78.2	74.1	65.4	81.6	77.1	75.7
New Shoreham, R. I	......	......	m80.6	73.6	67.8	71.3	71.4	75.2	76.7	65.2	82.6	81.2	......
New York City, N. Y	69.1	72.8	71.3	69.2	69.6	77.7	78.2	77.8	75.1	62.9	77.0	73.9	72.9
Norfolk, Va	67.8	73.8	70.4	66.8	73.7	74.8	78.3	70.8	63.1	66.2	71.7	68.9	70.5
North Platte, Nebr	61.6	58.5	60.7	57.7	63.0	70.0	69.8	73.7	70.3	57.9	65.9	66.2	64.6
Olympia, Wash	68.8	72.3	77.6	81.7	p86.3	88.5	83.8	87.1	81.8	77.5	68.3	72.8	78.9
Omaha, Nebr	61.4	65.3	66.5	63.8	68.3	73.2	77.1	79.4	74.6	69.6	70.3	65.8	69.6
Oswego, N. Y	68.8	70.2	69.7	67.4	72.0	73.5	74.6	74.3	76.3	64.6	74.5	71.8	71.5
Pembina, Dak	73.6	o76.0	......	......	......	......	......	......	......	......	......	......	......
Pensacola, Fla	75.4	76.1	77.0	75.2	76.2	72.1	78.8	72.5	64.9	77.3	70.3	74.5	74.2
Philadelphia, Pa	65.2	70.2	67.0	67.5	67.9	74.3	77.1	74.3	72.8	61.3	70.6	70.4	69.9
Pike's Peak, Colo	71.4	73.6	65.2	67.3	60.6	61.0	69.8	62.3	65.7	70.8	65.4	48.3	65.1
Pioche, Nev	19.1	23.1	27.6	30.2	36.1	66.8	54.4	43.0	38.1	32.5	25.1	13.0	34.1
Pittsburgh, Pa	66.8	70.0	70.2	70.4	75.2	78.1	80.4	71.2	69.7	63.5	62.9	69.0	70.6
Port Huron, Mich	73.4	75.3	73.1	74.6	79.0	80.0	80.5	79.8	81.9	72.7	74.5	76.3	76.8
Portland, Me	67.7	66.5	71.5	66.5	65.1	70.2	67.3	68.9	69.5	53.9	71.6	66.5	67.1
Portland, Oreg	61.8	68.7	70.6	81.7	74.4	79.3	78.2	81.5	73.8	67.5	54.0	66.4	71.5
Portsmouth, N. C	p79.3	q81.5	r87.8	s84.2	t83.3	u75.1	p83.9	73.7	80.1	82.4	78.5	81.6	81.0
Prescott, Ariz	41.3	46.6	40.8	38.0	42.1	63.8	47.3	38.1	43.7	36.4	24.4	18.0	40.0
Punta Rassa, Fla	71.4	75.3	73.2	72.6	79.9	72.9	78.2	71.0	67.6	70.4	68.8	70.7	72.7
Red Bluff, Cal	31.2	v32.5	36.7	36.9	43.8	87.2	73.4	79.3	60.3	66.5	44.1	40.3	52.7
Rochester, N. Y	61.8	65.4	65.8	70.5	74.5	80.2	79.6	77.6	80.0	62.2	70.0	68.5	71.3
Roseburg, Oreg	57.5	61.4	63.8	75.2	82.6	84.0	86.8	82.9	75.7	69.2	57.4	66.5	71.9
Sacramento, Cal	55.9	56.1	54.9	54.3	51.6	87.9	81.8	82.2	68.3	70.6	55.8	54.9	64.5
Salt Lake City, Utah	24.4	25.2	28.7	31.0	37.5	55.3	48.0	51.9	39.6	41.7	33.8	26.5	37.0
San Antonio, Tex	65.5	72.4	74.7	68.8	76.2	73.7	67.4	64.3	51.5	63.8	71.8	52.4	66.9
San Diego, Cal	75.3	77.2	78.4	69.9	59.1	73.3	65.5	72.5	73.0	71.4	68.4	69.2	71.1
Sandusky, Ohio	67.4	70.8	67.8	70.2	70.9	77.0	76.5	72.4	76.0	67.2	66.6	69.9	71.1
Sandy Hook, N. J	72.9	77.3	72.2	66.8	65.7	69.5	73.2	75.8	76.7	68.4	79.4	76.6	72.9
San Francisco, Cal	81.7	81.5	79.3	71.1	57.8	84.8	72.4	80.2	69.8	77.4	74.9	76.7	75.6
Santa Fé, N. Mex	40.2	49.2	46.6	48.0	55.2	55.7	60.3	56.8	48.7	32.7	35.8	20.2	45.8

a For 30 days only.
b Observations commenced December 3, 1880.
c Local Observations commenced January 1, 1881.
d Local observations discontinued March 31, 1881.
e Observations commenced January 3, 1881.
f Observations commenced December 1, 1880.
g For 28 days only.
h For 29 days only.
i Local observations discontinued July 31, 1880.
j For 8 days only; office destroyed by fire Nov. 17, 1880.
k Observations commenced January 1, 1881.
l For 30 days only.
m Observations commenced September 1, 1880.
n For 29 days only.
o Station closed September 3, 1880.
p For 25 days only.
q For 26 days only.
r For 24 days only.
s For 18 days only.
t For 21 days only.
u For 23 days only.
v August 16 to 31 only.

MONTHLY AND ANNUAL MEAN RELATIVE HUMIDITY, JULY, 1880, TO JUNE 1881, INCLUSIVE.—CONTINUED.

Station.	1880.						1881.						Annual mean.
	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	
Savannah, Ga.	69.1	75.5	76.3	76.2	79.2	69.4	75.8	63.9	56.0	62.4	69.5	63.2	69.7
Shreveport, La.	73.4	71.9	78.9	70.9	69.2	71.3	71.0	72.0	61.5	62.9	74.6	64.9	70.2
Smithville, N. C.	71.1	78.5	76.1	74.7	81.1	77.7	82.3	78.4	73.2	85.0	81.3	76.2	78.0
Springfield, Ill.	61.7	59.6	61.9	58.7	63.2	69.1	67.7	70.6	70.9	67.1	64.2	71.5	65.5
Springfield, Mass.	70.9	74.1	73.4	70.9	65.0	63.7	63.7	65.1	68.2	63.1	72.6	68.1	68.2
Saint Louis, Mo.	60.9	60.6	62.7	60.7	70.6	75.2	77.0	78.2	71.5	65.8	66.1	69.0	68.2
Saint Paul, Minn.	71.0	68.6	64.6	63.0	69.7	74.9	72.8	72.5	72.1	60.5	64.6	68.0	68.5
Saint Michaels, Alaska	86.8	88.6	90.6	95.7	96.1	98.8	99.3	100.0	97.6	98.6	97.8	82.3	94.4
Sitka, Alaska	......	......	......	......	......	......	......	......	......	a72.8	80.3	80.6	......
Saint Vincent, Minn.	......	......	g75.7	76.5	84.5	91.2	93.2	90.9	84.6	75.6	69.2	74.3	......
Socorro, N. Mex.	......	......	......	......	......	......	b52.3	47.1	c33.1	......	......	......	......
Thatcher's Island, Mass.	87.3	87.2	87.7	80.6	74.4	72.9	70.0	74.2	80.9	79.8	88.9	89.5	81.1
Toledo, Ohio	68.9	74.1	68.9	68.5	69.7	77.2	82.9	79.4	76.4	69.6	63.5	71.8	72.6
Umatilla, Oregon.	40.6	43.8	48.6	54.4	76.2	82.5	82.5	82.2	64.3	55.5	43.5	48.3	60.2
Vicksburgh, Miss.	72.0	75.8	81.3	75.8	77.8	74.9	72.2	68.6	57.1	58.6	63.7	63.2	70.1
Virginia City, Mont.	36.9	36.9	31.4	48.7	d62.4	......	......	......	......	......	......	......	......
Visalia, Cal.	41.6	38.1	41.1	54.7	58.8	81.3	80.3	77.1	66.4	64.7	45.7	40.8	57.5
Washington, D. C.	65.1	70.8	68.9	67.9	71.2	74.2	77.6	73.4	67.3	66.0	69.3	72.8	70.4
Wilmington, N. C.	73.4	79.3	72.3	71.9	80.5	74.4	74.7	66.4	59.2	62.6	71.1	72.2	71.5
Winnemucca, Nev.	17.8	16.6	18.7	32.9	46.7	e77.7	64.1	62.3	49.4	40.2	32.6	27.0	40.5
Wood's Holl, Mass	81.9	83.0	80.8	71.5	70.5	74.2	74.6	76.3	75.8	69.3	81.8	81.5	76.8
Yankton, Dak.	61.9	60.5	58.8	62.1	65.1	69.2	69.8	76.2	77.8	72.9	65.9	68.2	67.4
Yuma, Ariz	......	......	......	......	......	......	......	f40.0	41.9	43.0	38.7	36.4	......

a Observations commenced April 1, 1881.
b Local observations commenced January 1, 1881.
c Local observations discontinued March 19, 1881.
d Office removed to Eagle Rock, Idaho, Nov. 19, 1880.
e For 3 days only; office and records destroyed by fire; observations recommenced Dec. 28, 1880.
f Local observations commenced Feb. 1, 1881.
g Observations commenced Sept. 4, 1880.

MONTHLY AND ANNUAL AMOUNTS OF PRECIPITATION (IN INCHES AND HUNDREDTHS) FROM JULY, 1880, TO JUNE, 1881, INCLUSIVE.—(U. S. SIGNAL SERVICE.)

Station.	Elevation of rain gauge above ground, feet.	1880.						1881.						Annual amount.
		July.	August.	September.	October.	November.	December.	January.	February.	March	April.	May	June.	
Albany, N. Y.	70	3.78	2.84	2.86	2.45	2.49	2.01	2.86	2.50	3.80	1.34	3.90	3.76	34.59
Alpena, Mich.	52	6.14	1.61	3.31	1.95	2.49	1.85	1.59	5.01	3.01	.88	5.02	3.23	36.15
Atlanta, Ga.	92	3.16	3.61	6.21	2.81	8.21	5.70	8.35	10.41	10.98	4.58	1.27	2.46	67.75
Atlantic City, N. J	37	5.80	4.42	3.14	4.62	4.03	8.20	7.18	5.03	4.71	2.85	1.68	3.82	55.48
Augusta, Ga	40	5.98	5.10	1.04	2.03	5.31	4.13	8.69	3.98	7.54	4.71	1.35	2.11	51.97
Baltimore, Md.	69	6.47	4.41	1.78	2.64	2.86	4.89	4.84	5.68	7.59	2.00	2.30	7.81	53.30
Barnegat, N. J.	8	5.78	6.15	3.14	4.05	4.35	5.95	8.43	5.39	7.58	1.36	1.77	6.18	60.13
Bismarck, Dak.	1	2.02	4.82	.72	.27	.87	1.17	.69	.78	.45	1.02	2.27	4.11	19.19
Boise City, Idaho	32	.02	.02	.11	.50	.48	4.01	3.62	3.51	.64	1.34	.07	.29	14.61
Boston, Mass.	162	6.86	2.90	2.36	3.15	2.30	3.42	7.21	4.89	9.86	1.66	4.16	7.79	56.56
Brackettville, Tex.	4	5.35	4.29	1.77	.27	1.63	1.33	.35	.39	.81	3.43	5.29	.01	24.92
Breckenridge, Minn.	2	2.52	3.67	.68	1.78	.73	(a)	....	....	....	....	....	....	....
Brownsville, Tex.	40	3.64	16.58	1.90	3.82	3.44	.58	2.73	1.18	.20	.30	3.43	(b)	37.80
Buffalo, N. Y.	67	3.31	6.07	2.96	4.87	3.17	3.03	2.31	2.43	3.74	.76	2.18	4.15	38.98
Burkes, Ariz.	12	.04	.48	.68	(b)	.00	(c)	....	....	....	....	....	....	....
Burlington, Vt.	72	2.30	2.26	3.26	6.22	2.57	.62	.88	1.79	1.56	.62	2.27	1.89	26.24
Cairo, Ill.	78	4.34	2.61	4.55	6.96	3.98	2.22	3.56	4.97	1.33	3.62	2.44	1.81	42.39
Campo, Cal.	2	.12	.41	.01	.68	.85	4.85	1.74	.53	5.00	1.52	.12	.04	15.87
Camp Thomas, Ariz.	....	.87	2.49	.55	.18	.03	1.27	.03	.13	1.21	.63	.07	.00	7.46
Cape Hatteras, N. C.	1	9.06	16.30	3.65	12.00	12.68	(a)	....	....	....	....	....	....	....
Cape Henry, Va.	14	6.27	9.36	4.17	3.61	8.11	7.10	4.03	4.06	4.66	6.03	1.34	3.93	62.67
Cape Lookout, N. C.	1	7.11	4.43	5.04	7.90	7.61	d2.11	....	....	....	....	....	....	....
Cape May, N. J.	6	4.58	7.49	2.91	5.07	4.79	9.21	7.36	4.23	4.94	1.34	3.51	5.11	60.54
Castroville, Tex.	8	7.74	6.69	3.95	1.34	1.76	.29	.45	.85	.58	3.06	3.69	(b)	30.40
Cedar Keys, Fla.	35	9.10	19.45	4.41	10.37	6.29	5.05	9.36	3.51	3.86	3.45	2.25	1.69	78.79
Champaign, Ill.	....	....	....	....	e.64	1.80	1.53	.89	6.49	5.30	1.36	3.63	4.71	....
Charleston, S. C.	57	5.77	3.07	4.89	9.19	5.50	3.41	5.98	1.56	4.11	3.37	.48	1.47	48.80
Charlotte, N. C.	47	5.62	10.57	1.84	2.94	5.96	6.42	6.81	3.95	3.77	3.61	2.26	1.35	55.10
Chattanooga, Tenn.	59	5.13	3.33	5.20	1.69	8.82	5.46	4.70	6.19	6.85	4.56	4.46	5.24	61.63
Cheyenne, Wyo.	24	1.88	2.23	1.05	.76	.36	.08	.36	.22	.32	2.32	1.14	1.22	11.94
Chicago, Ill	92	3.07	4.47	2.25	3.09	.87	1.01	.87	5.98	2.99	1.84	1.85	5.93	31.22
Chincoteague, Va.	30	4.67	8.32	3.36	3.58	4.50	7.01	4.04	4.72	4.22	4.33	1.73	2.34	52.82
Cincinnati, O.	76	2.46	4.01	1.37	2.98	4.42	4.26	3.76	4.95	3.51	3.25	2.23	7.82	45.02

a Station closed November 30, 1880.
b Too small to measure.
c Station closed December 4, 1880.
d Observations discontinued December 31, 1881.
e Observations commenced October 13, 1880.

MONTHLY AND ANNUAL AMOUNTS OF PRECIPITATION, &C. FROM JULY, 1880, TO JUNE, 1881, INCLUSIVE.—CONTINUED.

Station.	Elevation of rain gauge above ground, feet.	1880.						1881.						Annual amount.
		July.	August.	September.	October.	November.	December.	January.	February.	March	April.	May	June.	
Cleveland, Ohio	74	4.75	3.97	2.98	2.24	2.27	1.51	1.96	2.57	2.82	1.75	.74	8.07	35.63
Coleman City, Tex	0	3.13	1.78	7.05	1.78	1.46	1.90	.36	.61	.55	1.65	2.70	b .02	22.99
Columbus, Ohio	70	4.86	6.95	1.80	2.35	4.54	3.98	2.25	4.44	4.01	2.04	2.00	4.02	43.24
Concho, Tex	0	10.26	2.25	7.45	2.62	1.33	.70	.22	.51	.28	1.87	6.82	.27	34.58
Corsicana, Tex	30	3.43	.58	7.75	1.92	5.54	.64	2.20	3.37	2.71	3.73	14.33	.00	46.20
Davenport, Iowa	77	4.31	5.90	4.87	.94	1.23	1.15	1.34	4.14	3.33	1.11	1.34	7.94	37.60
Dayton, Wash	2	1.68	1.29	.19	1.65	2.00	7.93	5.03	5.04	1.84	3.51	4.55	1.61	25.22
Deadwood, Dak	24	1.51	3.33	.30	1.27	2.37	.64	3.10	1.26	2.59	2.05	3.70	3.04	25.16
Decatur, Tex	5	3.79	.14	9.13	1.65	1.31	.62	.93	3.78	1.81	2.98	5.82	.01	31.97
Delaware Breakwater, Del.	27	5.30	5.06	1.23	3.84	2.61	3.29	4.39	2.92	2.94	1.08	1.23	3.44	37.33
Denison, Tex	28	5.89	2.14	6.74	2.53	3.21	.82	.74	4.85	1.62	3.31	8.03	.00	39.88
Denver, Colo	86	1.38	1.46	.89	1.37	.83	.10	.49	1.22	.87	.50	2.21	.09	11.41
Des Moines, Iowa	45	3.82	6.69	5.34	4.90	1.97	.86	1.55	2.68	1.78	3.36	3.82	15.79	52.56
Detroit, Mich	71	5.74	5.51	4.26	5.45	3.02	1.22	2.39	6.41	3.36	2.37	2.45	5.90	48.08
Dodge City, Kans	30	4.00	5.17	.32	1.42	2.43	.03	.15	1.63	.50	2.38	12.82	1.77	32.62
Dubuque, Iowa	43	3.55	7.15	6.84	.66	2.11	1.25	1.87	3.75	3.78	1.30	2.20	7.56	42.02
Duluth, Minn	28	1.98	4.35	1.86	2.32	2.89	1.62	1.65	1.79	1.46	1.10	1.77	2.52	25.31
Eagle Pass, Tex	2	6.68	5.78	7.16	2.70	.55	.30	1.15	.34	.32	.87	8.16	.00	34.01
Eagle Rock, Idaho	1	......	......	......	......	......	c4.50	3.66	5.14	.97	3.13	.74	1.09	......
Eastport, Me	56	3.45	1.48	4.28	5.11	5.07	3.53	1.64	4.11	6.78	1.66	13.22	4.47	54.80
Edinburg, Tex	28	1.88	6.23	d2.38	e2.59	1.53	.11	2.79	f1.21	......	......	......	......	......
El Paso, Tex	14	6.54	3.60	.80	.47	.02	1.53	.35	.24	.01	.22	1.83	.02	15.63
Erie, Pa	61	3.06	4.04	5.01	3.56	4.45	1.25	2.10	1.93	2.39	1.26	2.16	6.37	37.58
Escanaba, Mich	38	2.80	3.38	2.84	1.14	2.39	2.23	1.91	2.10	1.09	.44	7.91	6.21	34.44
Florence, Ariz	4	1.22	.54	.55	.13	.00	1.20	.00	.03	1.98	.86	.13	.00	6.64
Fort Apache, Ariz	0	5.83	1.44	.55	.56	.03	2.38	.20	1.17	2.45	1.53	.35	(a)	16.49
Fort Assinniboine, Mont	......	......	g2.56	.37	.22	.60	1.61	2.29	.70	.38	.21	(h)	(h)	......
Fort Bennett, Dak	17	......	......	i.00	.15	.08	.55	.82	1.18	1.57	.93	4.09	3.07	15.21
Fort Benton, Mont	58	1.12	1.56	.32	1.09	1.44	1.39	2.27	.66	.29	.18	j1.43	3.46	......
Fort Buford, Dak	0	4.17	2.36	1.04	.90	.66	3.08	1.98	1.10	1.17	1.34	1.00	3.44	22.24
Fort Custer, Mont	32	2.51	2.55	.20	1.19	.54	1.27	2.84	.51	.17	.78	1.80	1.57	15.93
Fort Davis, Tex	2	10.11	5.57	3.16	.38	.56	.31	.50	.14	.27	1.04	6.31	.07	28.42
Fort Elliott, Tex	0	2.11	1.70	.54	2.40	.10	.35	.47	.74	(a)	1.26	5.27	.10	15.04
Fort Gibson, Ind. T	35	3.61	2.82	1.89	3.22	2.34	.68	1.76	4.14	2.28	2.64	6.96	3.80	36.14
Fort Grant, Ariz	1	5.63	3.37	1.01	.47	.00	1.57	.05	.33	.89	.84	.26	(a)	14.42
Fort Griffin, Tex	3	3.54	.40	2.43	1.11	2.13	1.20	.62	1.39	.17	3.71	3.70	.09	20.49
Fort Keogh, Mont	37	2.66	2.10	.07	.29	.56	1.12	2.35	.36	.31	.35	.76	4.44	15.37
Fort Macon, N. C	5	......	......	......	......	......	......	k5.66	4.09	5.29	4.56	1.74	7.71	......

Fort McKavett, Tex	21	6.78	2.41	5.20	2.34	1.61	.49	.12	.19	.51	2.27	5.26	.07	27.25
Fort Missoula, Mont.	....	....	....	....	....	....	l4.43	8.22	2.40	.47	1.38	.29	2.75	....
Fort St. Michaels, Alaska	1	.65	4.05	5.61	2.38	1.48	1.31	.06	.00	.01	.39	2.66	.65	19.25
Fort Shaw, Mont	24	1.51	1.11	.05	.25	.89	1.17	2.50	.49	.15	.35	1.46	3.76	13.69
Fort Sill, Ind. T	2	5.57	3.96	1.17	.54	.60	.63	1.92	3.45	1.28	2.63	6.04	.21	28.00
Fort Stevenson, Dak.	4	.83	1.96	1.08	.36	.88	.91	.72	.56	.14	.60	2.31	5.83	16.18
Fort Verde, Ariz.	4	1.85	.97	.19	.57	.13	1.56	.07	.12	2.64	.97	.07	(a)	9.14
Fredericksburgh, Tex	24	5.40	4.55	12.25	2.69	5.09	1.32	.95	.59	1.13	2.13	6.30	.00	42.40
Galveston, Tex	52	2.48	1.62	10.20	2.20	8.85	2.16	3.94	8.29	1.47	4.76	3.50	.03	49.50
Grand Haven, Mich	76	4.47	8.03	3.74	3.15	2.01	2.32	2.24	6.13	3.77	1.89	1.19	3.44	42.38
Hatteras, N. C	1	....	....	....	....	....	m4.46	7.27	5.87	6.04	6.88	1.13	4.99	....
Helena, Mont	29	.86	1.38	.00	1.23	.87	4.64	2.86	.51	.00	1.55	1.60	3.51	19.01
Henrietta, Tex	4	3.77	1.82	3.53	(n)	1.20	.51	.99	.86	.98	4.87	3.00	.88	....
Indianapolis, Ind	74	2.26	2.67	1.86	3.54	2.58	1.44	2.10	6.43	4.01	2.60	3.78	3.92	37.19
Indianola, Tex	40	4.83	7.45	8.21	3.42	4.18	.69	3.07	4.21	.29	3.29	2.02	.00	41.66
Jacksboro', Tex	18	....	o.97	13.95	p4.97	1.58	.51	.48	2.08	2.23	2.36	3.53	.04	....
Jacksonville, Fla	57	5.94	8.96	5.21	16.25	6.09	1.29	9.12	1.12	2.89	4.57	2.61	2.82	66.87
Keokuk, Iowa	60	2.25	3.81	3.21	2.02	1.13	.67	.50	2.58	2.42	3.12	1.35	8.70	31.76
Key West, Fla	52	4.61	7.30	3.59	2.81	1.95	.71	3.65	.35	.46	4.99	4.01	7.47	41.90
Kittyhawk, N. C	1	9.94	11.18	5.03	5.95	9.92	5.74	7.34	3.97	4.24	4.97	.80	5.06	74.14
Knoxville, Tenn	77	6.28	4.45	3.64	.71	6.46	3.74	4.41	4.20	3.90	2.99	1.14	5.13	47.05
La Crosse, Wis	67	3.22	4.42	3.22	1.37	2.40	.71	1.51	1.26	1.01	1.35	3.13	2.75	26.35
La Mesilla, N. Mex	16	1.92	1.03	1.02	.35	.13	1.11	.04	(q)	.14	.09	1.75	.43	8.01
Laredo, Tex.	5	5.81	8.03	1.05	.72	1.07	.58	3.15	.31	.27	2.53	7.75	.00	31.27
Leavenworth, Kans	48	6.86	7.06	2.78	3.69	2.40	.40	.44	4.84	2.21	1.86	3.65	5.27	41.46
Lewiston, Idaho	38	1.86	1.09	.20	1.54	2.33	6.31	4.46	4.33	.49	2.60	.23	2.30	27.74
Little Rock, Ark	57	3.30	5.53	5.00	2.10	6.84	3.03	2.07	6.34	2.38	1.94	5.51	6.02	50.06
Los Angeles, Cal	50	(q)	(q)	.00	.14	.67	8.40	1.43	.36	1.66	.46	.01	.00	13.13
Louisville, Ky.	102	2.18	2.82	2.44	6.39	3.83	3.52	3.24	4.05	2.46	3.45	2.35	3.78	40.51
Lynchburgh, Va	50	5.75	3.20	1.57	1.33	3.26	1.63	4.47	2.37	2.57	2.14	2.20	1.67	32.16
Madison, Wis	57	6.00	5.90	4.44	1.68	1.68	1.17	2.05	5.42	4.36	1.50	4.25	4.15	42.60
Mason, Tex	2	5.49	4.22	10.39	2.16	2.14	.73	.37	.70	.85	2.95	5.29	.00	35.29
Marquette, Mich.	57	3.72	3.79	2.83	2.36	1.48	1.27	1.69	2.80	3.84	.52	4.47	3.47	32.24
Memphis, Tenn	51	2.14	3.03	2.47	5.20	8.39	2.62	4.38	6.41	3.23	5.74	2.80	2.83	49.24
Milwaukee, Wis	135	3.20	3.54	1.85	.51	.82	.74	1.86	5.39	5.30	.78	2.55	3.77	30.31
Mobile, Ala	85	4.92	4.75	7.04	7.32	(r)	3.71	7.62	8.00	10.41	9.21	1.44	4.85	....
Montgomery, Ala	58	3.17	4.41	2.83	2.66	4.06	5.68	3.58	7.05	5.45	4.52	1.41	3.04	47.86
Moorhead, Minn	41	....	....	....	....	....	....	s.60	2.13	.62	.77	2.80	5.59	....
Morgantown, W. Va	1	3.80	7.25	3.18	3.07	1.99	3.99	3.08	3.56	2.12	2.30	3.28	4.77	42.39
Mount Washington, N. H.	36	7.24	5.82	15.23	7.96	9.37	7.80	3.94	6.62	8.51	5.08	12.50	7.03	97.10
Nashville, Tenn	49	5.69	2.22	5.39	7.24	5.77	3.32	3.54	5.48	2.79	5.12	3.67	3.70	53.93
New Haven, Conn	108	4.90	8.14	3.73	4.07	2.82	3.49	4.79	6.17	10.42	1.71	3.89	5.14	59.27
New London, Conn	57	5.59	6.53	3.06	4.14	2.05	4.03	6.76	7.06	8.07	2.23	4.85	3.75	58.12
New Orleans, La	77	11.22	4.60	7.48	1.88	6.04	6.45	11.15	5.80	2.75	3.92	3.20	2.84	67.33

a Too small to measure.
b Station closed July 27, 1881.
c Observations commenced December 3, 1880.
d For 14 days only.
e For 20 days only.
f Station closed February 12, 1881.
g No mail reports received prior to August 1, 1881.
h Data incomplete; observer sick.
i Observations commenced September 27, 1880.
j May 20 to 31 only.
k Observations commenced January 3, 1881.
l No rain-gauge at this station during prior months.
m Observations commenced December 1, 1880.
n Record for October incomplete.
o For 24 days only.
p For 25 days only.
q Too small to measure.
r Office destroyed by fire November 17, 1880, no record of rain-fall during month.
s Observations commenced January 1, 1881.

MONTHLY AND ANNUAL AMOUNTS OF PRECIPITATION, &C., FROM JULY, 1880, TO JUNE 1881, INCLUSIVE.—CONTINUED.

Station.	Elevation of rain gauge above ground, feet.	1880. July.	August.	September.	October.	November.	December.	1881. January.	February.	March.	April.	May.	June.	Annual amount.
Newport, R. I.	43	5.86	7.15	2.80	3.59	4.01	4.87	5.70	8.28	8.24	2.11	2.90	5.94	61.45
New Shoreham, R. I	23	......	......	b4.04	4.62	4.02	4.42	2 16	4.74	5.08	1.91	5.51	12.93	......
New York, N. Y	145	6.67	4.40	2.26	2.81	2.40	4.15	5.41	5.06	6.78	1.00	2.33	6.23	49 50
Norfolk, Va	52	7.84	9.90	4.07	3.08	5.64	5.15	3.55	2.88	3.38	4.06	1.49	3.74	54.78
North Platte, Nebr	8	2.87	3.96	1.53	2.72	.23	.37	.16	.76	1.26	.87	4.84	6.12	25.69
Olympia, Wash	38	.52	.22	1.05	2.83	3.06	16.66	8.90	16.28	4.03	4.93	1.54	1.93	61.95
Omaha, Nebr	75	5.36	7.10	2.91	3.54	.70	.28	.61	3.09	.72	4.23	7.94	5.56	42.04
Oswego, N Y.	62	1.74	3.25	1.51	4.32	6.45	4.24	4.15	4.74	5.08	1.19	2.41	2.98	42.06
Pembina, Dak	18	4.75	4.34	(c)	......	......	......	......	......	......	......	......	......	......
Pensacola, Fla	36	7.39	4.68	11.54	7.08	5.86	2.24	7.49	8.99	3.80	4.53	1.40	4.27	69.27
Philadelphia, Pa	95	7.74	5.09	1.10	1.74	1.75	4.05	3.66	4.76	3.83	0.61	2.71	3.87	40.91
Phœnix, Ariz	19	1.18	.72	.67	.20	.00	1.61	.00	.20	1.46	1.10	0.12	.00	7.26
Pike's Peak, Colo	1	6 69	4.30	3.87	4.64	4.07	1.69	2.58	1.47	4.44	4.64	3.71	.87	42.97
Pilot Point, Tex	36	2.42	1.38	7.63	1 88	2.16	.93	.75	5.96	2.72	(d)	......	......	......
Pioche, Nev	23	.18	.47	.18	.52	.29	1.84	.47	.29	.47	1.08	.21	.03	6.03
Pittsburgh, Pa	86	2.15	3.62	3.12	2.80	1.73	2.95	3.55	3.45	3.35	1.81	2.34	6.95	37.82
Port Huron, Mich	63	4 97	4.51	2.17	4.06	2.79	1.23	3.50	4.91	4.60	.76	1.66	3.82	38.98
Port Eads, La.	2	......	......	......	......	......	......	......	......	......	e7.18	.41	.94	......
Portland, Me	77	3 12	2.32	3.20	4.21	3.25	3.17	4.30	5.30	5.09	1.43	5.64	3.99	45.02
Portland, Oreg.	60	.59	1.31	1.34	1.47	3.17	13.93	8.57	13.36	2.83	3.51	1.38	2.34	53.80
Portsmouth, N. C.	29	3.94	9.56	7.87	5.12	6.17	2.49	2.72	5.98	6.57	4.70	2.13	4.95	62.20
Prescott, Ariz	5	2.34	2.80	1.26	.18	.42	1.84	.16	.10	2.91	.67	.44	(a)	13.12
Punta Rassa, Fla	35	3.76	8.55	2.50	8.10	1.81	1.98	4.02	.52	1.18	.54	3.13	2.53	38.62
Red Bluff, Cal	32	.00	f 00	.00	.08	.14	12.85	9.40	2.79	.51	1.83	.79	.51	28.90
Rio Grande City, Tex	0	.96	9.13	2 05	1.48	1.15	.35	3.48	1.06	.07	2.12	2.93	(a)	24.78
Rochester, N. Y	96	3.49	5.53	2.72	5.31	3.19	2.99	4.68	2.86	5.33	1.15	5.86	3.20	46.31
Roseburg, Oreg	32	.01	.41	.47	.77	.77	8.29	11.60	8.19	1.95	1.07	.73	2 92	37.18
Sacramento, Cal	54	(a)	.00	.00	.00	.05	11.81	6.14	5.06	1.37	1.64	(a)	.50	26.57
Salt Lake City, Utah	75	.20	.74	.56	.40	1.17	1.90	1.24	2.44	.88	2.37	2.55	.28	14.73
San Antonio, Tex	33	6.30	8.67	2 93	2.35	2.06	.40	.58	1.24	1.06	3.25	4.70	(a)	33.54
San Diego, Cal	30	.09	.32	.00	.53	.28	4.15	.52	.45	1.88	1.35	.04	.05	9.66
Sandusky, Ohio	66	6.06	5.03	2.02	2.27	2.39	1.06	1.31	3.25	2.75	2.47	.98	10 09	39.68
Sandy Hook, N. J.	1	6.43	4.26	3.35	3.97	3.76	2.51	5.03	5.37	6.92	1.41	3.33	6.80	53.14
San Francisco, Cal	75	.00	.00	.00	.05	.33	12.33	8.69	4.65	.90	2.00	.22	.69	29.86
Santa Fé, N. M	18	2.69	1.79	1.13	.75	.28	.66	.38	.22	.57	.98	2.31	.08	11.84
Savannah, Ga	58	7.24	3 94	4 65	6.58	4.40	7.48	5 77	1.16	3.79	3.32	.83	.91	50.07
Shreveport, La	44	10.97	1.21	11 61	2.72	7.43	2.24	2.24	6.51	1.80	2.81	8.63	.38	58.55
Silver City, N. M	1	3.05	3.51	3.57	1.66	.00	1.65	.02	.73	.91	.48	1.01	.43	17.02

Sitka, Alaska	96	....	....	....	....	....	....	....	....	....	*g*4.21	3.70	1.54	....
Smithville, N. C.	35	5.69	7.49	3.33	6.62	4.77	2.88	6.05	2.31	3.92	4.76	2.25	.52	50.59
Socorro, N. Mex.	13	3.85	(*h*)	2.07	2.81	.81	3.54	.55	.01	.07	.23	*i*.51	....	....
Spokane Falls, Wash.	....	....	....	....	....	....	....	....	*j*3.85	1.07	1.20	.50	1.23	....
Springfield, Ill.	61	1.82	1.80	3.15	2.04	1.60	1.10	.84	5 85	4.15	1.96	2 86	4.90	32.43
Springfield, Mass.	64	6.55	3.46	2.65	4.31	3.57	1.82	3.16	4.50	4.40	2.49	4.85	9.07	50.83
St. Paul's Island, Alaska.	1	....	....	....	....	....	....	....	....	....	....	....	2.22	....
St. Louis, Mo.	100	5.17	1.53	3.10	2.09	2.67	1.80	.49	4.16	1.95	3.14	3.96	2.74	32.80
St. Paul, Minn.	58	2.75	3.63	1.74	2.18	2.93	2.69	4.31	2.65	1.06	.47	4.34	2.87	31.65
St. Vincent, Minn.	14	....	....	*k*2.19	2.69	.07	.73	.13	.56	.08	.81	4.00	3.47	....
Stockton, Tex.	2	7.27	6.86	13.30	.91	1.76	.34	.20	.13	.06	.46	2.26	1.05	31.60
Thatcher's Island, Mass.	4	6.51	4.15	3.72	2.81	4.32	2.81	4.56	4.73	9.96	1.56	7.22	7.51	59.86
Toledo, Ohio	105	6.22	4.65	1.23	3.31	1.71	.69	.54	4.28	1.90	1.76	.45	7.36	34.13
Tucson, Ariz.	16	1.62	1.28	1.89	.09	.00	.57	.05	.25	1.17	.62	.04	.00	7.58
Umatilla, Oreg.	3	.48	1.14	.18	.35	.54	3.65	2.45	1.92	.44	.89	.06	.96	13.06
Uvalde, Tex.	0	4.82	5.71	4.46	.44	1.64	1.23	.43	.82	.59	2.39	6.44	.00	28.97
Vicksburg, Miss.	53	4.89	5.67	10.51	5.75	14.15	4.10	3.37	7.20	3.53	1.48	4.39	1.94	66.98
Virginia City, Mont.	29	2.06	.82	.14	2.46	*l*1.29	....	....	....	....	....	....	....	....
Visalia, Cal.	44	(*a*)	.00	.00	.13	.35	5.03	2.71	1.10	1.20	.86	.29	.00	11.67
Washington, D. C.	51	2.25	3.83	3.42	2.31	2.48	4.02	5.14	4.01	6.61	2.08	1.86	5.71	43.72
Wickenburg, Ariz.	2	2 29	.61	.89	.08	.00	1.23	.07	.00	1.70	.70	.07	(*a*)	7.64
Wilmington, N. C.	45	9.20	8.79	1.20	5.28	5.30	1.52	5.06	2 80	5.14	3.47	2.11	3.48	53.35
Winnemucca, Nev	5	.00	.02	.00	.00	.10	1.88	3.08	1.59	.87	1.04	1.02	.62	10.22
Wood's Holl, Mass.	34	3.77	5.39	1.27	3.18	1.69	3.03	2.57	5.46	4.22	2.12	2.39	6.25	41.34
Yankton, Dak.	28	3.32	3.04	.98	1.98	.21	.99	1.13	2.70	1.74	2.49	9.88	3.51	31.97
Yuma, Ariz.	26	(*a*)	(*a*)	(*a*)	(*a*)	.00	.74	.00	(*a*)	(*a*)	.55	.00	(*a*)	1.29

a Too small to measure.
b Observations commenced September 1, 1880.
c Station closed September 3, 1880.
d Station closed.
e Observations commenced April 10, 1881.
f August 16 to 31 only.
g Observations commenced March 30, 1881.
h Record of rain-fall for August incomplete.
i Station closed May 23, 1881.
j Observations commenced February 1, 1881.
k Observations commenced September 4, 1880.
l Office moved to Eagle Rock, Idaho, on Nov. 19, 1880.

ELEVATIONS OF SIGNAL SERVICE BAROMETERS ABOVE MEAN SEA-LEVEL ON JUNE 30, 1881, AND OF THERMOMETERS AND RAIN GAUGES ABOVE GROUND (U. S. SIGNAL SERVICE).

Station.	Above sea-level.	Above ground.	
	Barometer.	Therm.	Rain-gauge.
	Feet.	*Feet.*	*Feet.*
Albany, N. Y	75.3	50.9	69.7
Alpena, Mich	609.4	54.4	52.0
Atlanta, Ga	1,131.3	77.7	92.2
Atlantic City, N. J	12.9	9.7	37.2
Augusta, Ga	182.8	18.1	39.8
Baltimore, Md	45.2	33.1	69.1
Barnegat, N. J	20.0	5.5	7.6
Benton, Mont	....	50.5	58.0
Bismarck, Dak	1,704.3	16.4	.5
Boerne, Tex	1,508.0 B.	6.5	4.5
Boise City, Idaho	2,768.0 B.	19.3	32.1
Boston, Mass	142.2	155.9	161.6
Brackettsville, Tex	1,137.0 B.	6.4	3.5
Brownsville, Tex	43.4 ?	20.2	40.4
Buffalo, N. Y	664.5	72.0	67.2
Burlington, Vt	268.0	54.6	72.0
Cairo, Ill	377.3	44.4	77.6
Campo, Cal	2,527.0	5.0	2.1
Cape Hatteras, N. C	8.4	7.0	1.0
Cape Henry, Va	16.0	16.5	14.3
Cape Lookout, N. C	15.0	18.0	1.0
Cape May, N. J	27.0	18.6	6.1
Castroville, Tex	778.0 B.	16.0	8.0
Cedar Keys, Fla	22.5	20.3	34.7
Charleston, S. C	52.5	40.5	56.6
Charlotte, N. C	837.8 ?	34.6	47.0
Chattanooga, Tenn	783.2	42.6	59.2
Cheyenne, Wyo	6,089.0	15.3	24.0
Chicago, Ill	660.9	69.2	92.0
Chincoteague, Va	18.5	28.9	29.7
Cincinnati, Ohio	620.4	67.8	76.3
Cleveland, Ohio	689.7	78.5	74.0
Coleman City, Tex	1,735.0 B.	4.1	....
Columbus, Ohio	804.6	52.0	70.0
Concho, Tex	1,888.0 B.	5.6	On ground.
Corsicana, Tex	447.5	18.6	30.0
Davenport, Iowa	614.7	46.1	77.0
Dayton, Wash	1,700.0 B.	5.8	1.7
Deadwood, Dak	4,630.0 B.	15.7	23.9
Decatur, Tex	1,160.0 ?	17.0	5.0
Delaware Breakwater, Del	20.0	12.8	26.6
Denison, Tex	767.4	16.8	28.2
Denver, Colo	5,293.6	45.3	56.1
Des Moines, Iowa	849.0	35.0	45.3
Detroit, Mich	661.4	61.4	71.1
Dodge City, Kans	2,512.5	15.3	29.9
Dubuque, Iowa	665.1	31.9	43.1
Duluth, Minn	644.1	18.9	27.7
Eagle Pass, Tex	800.0 B.	5.3	.1
Eagle Rock, Idaho	4,780.6	12.2	1.0
Eastport, Me	61.2	32.5	55.5
El Paso, Tex	3,956.0 B.	16.8	14.1
Erie, Pa	681.1	31.6	60.6
Escanaba, Mich	611.6	24.9	38.2
Florence, Ariz	1,553.0 B.	4.9	3.9
Fort Apache, Ariz	5,004.0	7.0	.1
Fort Assinniboine, Mont	....	4.9	Not up.
Fort Bennett, Dak	....	12.0	17.0
Fort Buford, Dak	1,876.0 B.	7.8	....
Fort Custer, Mont	3,100.0 B.	....	....
Fort Davis, Tex	4,918.0 B.	3.2	2.0
Fort Elliott, Tex	....	6.4	On ground.
Fort Gibson, Ind. T	510.1	19.1	35.4
Fort Grant, Ariz	4,737.0 B.	5.6	10.0
Fort Griffin, Tex	1,243.0 B.	7.0	3.0
Fort Keogh, Mont	....	13.8	37.0
Fort Macon, N. C	11.0	8.1	4.8
Fort McKavett, Tex	....	4.1	21.1
Fort Missoula, Mont	....	6 9	....
Fort Shaw, Mont	....	....	....

ELEVATION OF SIGNAL BAROMETERS ABOVE MEAN SEA-LEVEL, &C.—*Continued.*

Station.	Above sea-level.	Above ground.	
	Barometer.	Therm.	Rain-gauge.
	Feet.	*Feet.*	*Feet.*
Fort Sill, Ind. T	1,190.0 B.	5.5	2.0
Fort Stevenson, Mont	1,734.0 B.	7.5	4.5
Fort Verde, Ariz	3,105.0 B.	5.5	3.6
Fredericksburg, Tex	1,742.0 B.	15.8	24.0
Galveston, Tex	39.5	36.1	51.5
Grand Haven, Mich	620.2	22.6	75.8
Hatteras, N. C	19.5	6.3	1.0
Helena, Mont	4,315.6 B.	......	......
Henrietta, Tex	915.0 B.	4.0	3.5
Huron, Dak	1,300.0 ?	......	......
Indianapolis, Ind	753.3	52.2	73.5
Indianola, Tex	25.9	29.2	39.9
Jacksboro, Tex	1,133.0 B.	5.8	17.5
Jacksonville, Fla	43.0	37.4	57.0
Keokuk, Iowa	617.6	46.9	59.5
Key West, Fla	26.9	42.9	52.1
Kittyhawk, N. C	22.0	3.9	1.0
Knoxville, Tenn	980.0	72.4	77.4
La Crosse, Wis	708.0	40.0	67.0
La Mesilla, N. Mex	4,124.0 B.	17.8	16.0
Laredo, Tex	401.0 B.	4.2	5.2
Leavenworth, Kans	841.9	34.5	48.0
Lewiston, Idaho	619.0 ?	22.5	37.6
Little Rock, Ark	298.2	25.6	57.2
Los Angeles, Cal	350.1	36.6	50.0
Louisville, Ky	530.0	89.3	102.5
Lynchburgh, Va	651.5	30.5	50.0
Madison, Wis	949.2	32.6	56.8
Marquette, Mich	672.9	36.4	56.7
Mason, Tex	1,620.0 B.	16.3	1.7
Memphis, Tenn	320.8	52.8	51.0
Milwaukee, Wis	697.1	105.4	134.8
Mobile, Ala	68.9	64.5	84.6
Montgomery, Ala	219.0	33.6	58.2
Moorhead, Minn	923.0	23.3	41.4
Morgantown, W. Va	962.6	10.2	1.0
Mount Washington, N. H	6,259.0 ?	6.0	2.0
Nashville, Tenn	507.0	34.1	49.0
New Haven, Conn	106.4	112.4	108.3
New London, Conn	46.6	28.6	57.2
New Orleans, La	52.4	45.3	77.1
Newport, R. I	44.4	19.1	43.0
New River Inlet, N. C	......	58.0	......
New Shoreham, R. I	27.4	8.2	22.8
New York, N. Y	164.3	147.8	144.9
Norfolk, Va	30.1	20.0	52.5
North Platte, Nebr	2,841.0	18.8	7.5
Olympia, Wash	36.0	22.9	38.2
Omaha, Nebr	1,113.3	59.2	74.6
Oswego, N. Y	304.2	34.7	62.2
Pensacola, Fla	29.8	20.0	36.2
Philadelphia, Pa	52.4	99.0	95.0
Phœnix, Ariz	1,068.0 B.	3.6	18.7
Pike's Peak, Colo	14,134.2	5.1	1.0
Pilot Point, Tex	800.0	17.2	35.6
Pioche, Nev	6,220.0 B.	5.0	22.6
Pittsburgh, Pa	762.2	87.7	85.6
Port Eads, La	7.1	7.0	2.0
Port Huron, Mich	632.9	80.0	63.0
Portland, Me	45.4	27.7	76.7
Portland, Oreg	67.0	44.9	59.8
Portsmouth, N. C	No bar......	8.1	29.4
Prescott, Ariz	5,339.0 B.	10.1	4.6
Punta Rassa, Fla	13.1	13.8	35.4
Red Bluff, Cal	323.9	20.8	31.9
Rio Grand City, Tex	......	4.9	.0
Rochester, N. Y	588.9	100.0	96.5
Roseburg, Oreg	537.0	20.0	32.8
Sacramento, Cal	69.6	37.6	54.4
Saint Louis, Mo	567.8	104 4	100.0
Saint Michaels, Alaska	30.0	13.0	.8
Saint Paul, Minn	810.9	32.0	58.0
Saint Vincent, Minn	804.0	8.8	14.0
Salt Lake City, Utah	4,348.0	52.5	74.6

ELEVATION OF SIGNAL BAROMETERS ABOVE MEAN SEA-LEVEL, &C.—*Continued.*

Station.	Above sea-level.	Above ground.	
	Barometer.	Therm.	Rain-gauge.
	Feet.	*Feet.*	*Feet.*
San Antonio, Tex	675.7	17.2	32.8
San Diego, Cal	67.1	19.0	30.5
Sandusky, Ohio	638.6	54.0	66.1
Sandy Hook, N. J	27.9	14.9	1.0
San Francisco, Cal	60.4	48.0	75.0
Santa Fé, N. Mex	7,046.0	20.8	18.5
Savannah, Ga	86.9	41.0	57.7
Shreveport, La	226.8	33.3	43.8
Silver City, N. Mex	5,796.0 B.	4.8	1.0
Sitka, Alaska	63.0	64.4	95.6
Smithville, N. C	33.7	17.6	35.4
Socorro, N. Mex	4,564.8	5.2	13.4
Springfield, Ill	644.0	38.8	60.9
Springfield, Mass	120.5	54.2	63.6
Spokane Falls, Wash	1,910.0	18.5	....
Stockton, Tex	3,063.0 B.	5.8	1.5
Thatcher's Island, Mass	48.1	7.0	4.0
Toledo, Ohio	651.2	63.5	104.7
Tuscon, Ariz	2,404.0	6.3	15.7
Umatilla, Oregon	384.0 B.	7.3	3.0
Unalaska, Alaska	13.4	15.3	1.3
Uvalde, Tex	891.0 B.	3.6	On ground.
Vicksburgh, Miss	242.6	32.5	52.6
Virginia City, Mont	5,810.0 B.	24.2	29.0
Visalia, Cal	348.1	22.4	44.5
Washington, D. C	104.6	44.1	50.8
Wickenburg, Ariz	1,400.0 B.	4.5	2.1
Wilmington, N. C	52.0	28.0	44.8
Winnemucca, Nev	4,327.3	7.0	5.0
Wood's Holl, Mass	35.0	6.1	34.0
Yankton, Dak	1,228.4	19.8	28.4
Yuma, Ariz	140.8	5.1	26.0

BAROMETRICAL REDUCTIONS TO SEA-LEVEL.

The hypsometric formula employed for the reduction to sea-level of barometric readings at all stations whose elevations are less than 1,150 feet is that of La Place, as given in Appendix I. to the Instructions in the Use of Meteorological Instruments, compiled by Robert H. Scott, from whose tables, there given, the reduction constants have been obtained.

For stations whose altitudes are greater than 1,150 feet, the constants were obtained with the aid of the following hypsometric formula:

$$h = 60368.75\ m\ (1.004455 + 0.000004698\ [t-32])\ (1+0.0026119 \cos 2\varphi) \times$$

$$\times \left(1+0.189\frac{e''}{b''}\,[1+10^{\frac{h}{10091}}]\right) \log \frac{b'}{b''}$$

In this formula, which has been obtained in the course of an investigation on barometric hypsometry now in progress in this office,

h = difference of altitude between the two stations in English feet.

m = a small factor modifying Boyle's (Mariotte's) law.

t = mean temperature of the column of air between the upper and lower stations in degrees of Fahrenheit.

φ = mean latitude of the stations.

$\frac{e''}{b''}$ = ratio of the vapor tension to the barometric pressure at the upper stations.

b', b'' = barometric pressure in inches at the lower and upper stations respectively.

In applying this formula to the reduction of barometric readings to sea-level we simply regard log. b' as the unknown quantity and substitute for h its value obtained by levelling or other measurements. The formula then becomes—

$$\log b' = \log b'' + \frac{h}{60368.75m\ (1.004455+0.000004698\ [t-32])\ (1+0.0026119 \cos 2\varphi)\left(1+0.189\frac{e''}{b''}\,[1+70^{\frac{h}{10091}}]\right)}$$

Let $A = 60368.75\ m\ (1.004455 + 0.000004698\ [t-32])$

$C = 1 + 0.0026119 \cos 2\varphi$

$D = 1+0.189\frac{e''}{b''}\,[1+10^{\frac{h}{10091}}]$

Then $\log b' = \log b'' + h.\ \frac{1}{A}.\frac{1}{C}.\frac{1}{D}.$

Manuscript tables have been computed for the factors $\frac{1}{A}$, $\frac{1}{C}$ and $\frac{1}{D}$ by which the computation of log. b', and consequently b'', is greatly

facilitated. The difference $b' - b''$ gives the required reduction to sea-level.

In the above formula, it is assumed that the value of t, or the mean temperature of the column of air between the upper and lower stations, is known. Any errors made in the methods by which this is obtained will affect the final results, but are not due to the formula itself, which makes no provision for obtaining the correct value of the mean temperature. As a simple approximation, the observed monthly mean temperatures at the Signal Service stations have been adopted as the mean temperatures of the column of air assumed to exist below the stations, with the exception only of Mount Washington, for which the mean of the temperatures at Burlington, Vt., and Portland, Me., has been adopted as the temperature at sea-level, and the mean between this value and the observed value at Mount Washington adopted as the mean temperature of the column of air.

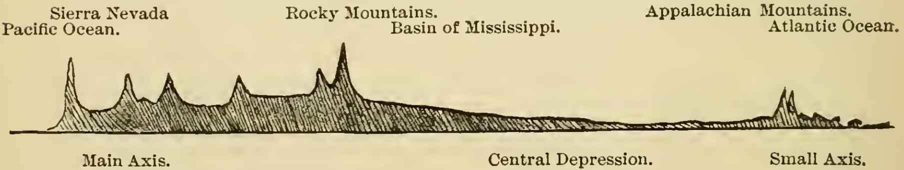
The climate of the United States is divisible into three regions: 1, the Atlantic States, east of Appalachian System, or Alleghany Mountains; 2, the Mississippi Basin, between the Alleghanies and the Rocky Mountains; 3, the Western Highlands, between the Rocky Mountains and the Pacific; and 4, the Pacific slope.

Prof. Guyot observes:

"Each continent has on one side a large system of highlands, plateaus, and mountain chains, which constitutes the principal feature of its structure, and may be called its main axis. On the other side, along the opposite shore, is found a similar system, but diminutive in all its dimensions, extending over only a part of the continent, and forming a secondary axis. Between the two a general depression, or low plain, fills the interior. The direction of these two fundamental lines of highlands is not parallel but converging, which gives to all continents a form more or less triangular.

"A large swell on one side, a smaller converging one on the other, and a depression between the two, is the *typical* form of a continent. An island, however large, is never more than a part of it.

"This typical structure can be traced in all continents, but in none more clearly than in North America.



"Here the main axis is formed by the large swell of the western highlands, stretching from the northwest to the southeast, without interruption, for 4,500 miles, steadily growing in height from the shores

of Alaska to the south end of Mexico, and filling from one-third to one-half of the width of the continent. The plateaus contained between the border chains of the Sierra Nevada and the Rocky Mountains average full 4,000 feet, and reach in Mexico double that altitude, the high peaks of the mountain ranges reaching from 12,000 to 15,000 feet. The secondary axis is the Appalachian system, extending from Nova Scotia to Alabama, in a southwesterly direction for 1,500 miles. Its average width is hardly one-fifth, and its elevation, plateaus, and peaks, not one-half that of the western highlands; but still it determines the trend of the Atlantic coast. Between the two axes, the lowlands of British America, and the vast plains of the Mississippi Basin stretch for 3,000 miles from the Arctic shores to the Gulf of Mexico, hardly interrupted by a slight central swell of a thousand or sixteen hundred feet in the region of the sources of the Mississippi." [1]

To duly appreciate the climatological influences of these regions, it is necessary to bear in mind that the differences in the nature of the surface throughout are exceedingly diverse—comprehending extensive coasts, great lakes, forests, prairies, arid plains, basins, and mountain ranges.

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[1] "Treatise on Physical Geography," by A. Guyot, LL.D., etc. (Johnston's Atlas), p. 28.

CHAPTER XV.

CLIMATOLOGICAL TOPOGRAPHY AND MINERAL SPRINGS OF THE ATLANTIC STATES.

THE rise of the Atlantic Slope begins in Georgia. From the seacoast about thirty miles inland the ground is low and swampy, and insalubrious; but at this distance there is an abrupt terrace-like rise of about seventy feet; this is followed by a succession of similar abrupt elevations at various distances apart, until about one hundred and sixty miles from the coast, where the elevation is from five hundred to six hundred feet. And it is here that the foot-hills of the Alleghanies begin, in a series of ascending ridges and outcropping spurs, which in the northern and northwestern part of the State attain an altitude of 2,500 to 5,000 feet above the level of the sea.

Atlanta is situated at an altitude of 1,078 feet above the level of the sea; latitude, 33° 54′ north; longitude, 7° 28′ west; in the midst of a healthy region on the divide of the water-shed separating the waters which enter the Gulf of Mexico through the Chatahoochee River, here distant eight miles from those which find the Atlantic through Proctor's Creek, the South and Ocmulgee Rivers. The Blue Ridge terminates about fifty miles to the northeast; and bifurcating from it westward are Sweet's Mountain, the Altatoona Range, Great and Little Kenesaw and Lost Mountains. All this region and thereabout is rolling and devoid of swamps. Its salubrity, however, has been somewhat impaired by the destruction of the forest which formerly obtained.

The Appalachian or Alleghany system of mountains, which here begins, consists of a belt of several parallel ridges and valleys from one hundred and fifty to two hundred miles wide, extending northward from Georgia through the Carolinas, Tennessee, Virginia, West Virginia, and Maryland, to Pennsylvania. It is everywhere equally well watered, and, naturally, woodland and cultivable throughout. The elevations in general are insufficiently continuous to cause any very decided contrasts on the opposite slopes. The temperature and rain-fall are consequently nearly equally distributed; the atmosphere is neither excessively moist nor excessively dry, and with various altitudes, from a few hundred to nearly 7,000 feet, a climate of remarkable salubrity obtains at all seasons.

Moreover, it is in this region that mineral waters of value abound. In Georgia, those of most note are:

The *Indian* Springs, in Butts County, a few miles from Macon. This water is sulphurous, and according to analysis by J. C. Colton one pint contains:—

SOLIDS.	Grains.
Carbonate of magnesia,	1.982
Sulphate of potassa,	3.415
Sulphate of magnesia,	71.528
Sulphate of lime,	7.152
	84.077

GASES.	Cubic inches.
Carbonic,	1.000
Sulphuretted hydrogen,	3.005
Nitrogen,	0.156

The *Merriweather Warm Springs*, in the County of Merriweather, twelve miles from Chipley, in the Pine Mountains. Temperature of water 95°. By analysis of Prof. A. Means, one pint contains:—

SOLIDS.	Grains.
Oxide of magnesia,	11.68
Oxide of calcium,	4.64
Protoxide of iron,	2.14
	18.46

GASES.	Cubic inches.
Carbonic,	1.11
Sulphuretted hydrogen,	trace.

Madison Springs, in Madison County; *Gordon's*, in Murray County; and *Rowland's*, in Cass County, are all *chalybeate* waters, of considerable repute; and the last is also said to contain saline matter. There are no reliable analyses of these waters.

In South Carolina, the face of the country is very similar to that of Georgia. From tide water to about eighty miles inland, it is low and alluvial; and, to a very considerable extent, swampy and insalubrious. But after this the land rises abruptly in successive terraces, alternating with beautiful valleys and rounded hills, until it reaches an average altitude of about 2,000 feet above the level of the sea, and a climate of rare salubrity all the year round. And for those who would seek a greater altitude in the same latitude, the highest peaks of the Blue Ridge Mountains, which run through the northwest part of the State, attain an altitude of 4,000 feet.

Columbia, at an altitude of only 300 feet above the level of the sea, latitude 34° north; longitude 4° 4′ west, has always been a favorite refuge for fugitives from Charleston in times of yellow fever; and with the ex-

ception of malarial fevers, due to removable causes, is generally healthy. And Aiken, 600 feet above the sea level, in the pine forest region, enjoys a wide and deserved repute as a winter resort for consumptives. The uplands generally, and especially the mountain slopes in the north-western part of the State, are naturally salubrious at all seasons.

Mineral Springs of considerable value are found in various parts of the State, chiefly *chalybeate*. Those of most repute are in the Abbeville and Laurens Districts, near Parson's Mountains; some sulphurous springs also exist in the same region: *Glenn's* Springs, in Spartansburg District, and *Chick's*, a few miles above Greenville, are *sulphurous*. Glenn's, besides the sulphates of magnesia and lime, also contain bi-carbonate and chloride of lime. All these are pleasantly situated in the upland and mountainous regions, and easy of access.

The Charleston artesian well waters, from a depth of over 2,000 feet, are *thermal* 99°5; and, on analysis of S. T. Robinson, Jr., assistant in the Laboratory for Analytical Chemistry of Prof. C. W. Shepard, one U. S. standard gallon, of 231 cubic inches and weighing 58.438 grains, on evaporation leaves a residue of 65.053727 grains, consisting of the following ingredients :—

Organic matter and water of crystallization,	1.733689
Carbonate of iron,	.335028
Sulphate of lime,	.442367
Sulphate of magnesia,	.165247
Chloride of magnesium,	.230291
Chloride of sodium,	11.390304
Carbonate of soda,	47.258488
Nitrate of soda,	.554260
Silicate of soda,	2.524745
Silica,	.361700
Total,	64.996119

North Carolina, along the coast, is deeply indented by sounds and broad-mouthed rivers, with low-lying alluvial soil between, in some places marshy and insalubrious, but in others covered by dense pine and cypress forests, almost at the level of the sea, which, in the interior, are salubrious notwithstanding their low level and great dampness. Of such are the Great and Little Dismal Swamps extending from this State into Virginia, embracing an area of 3,000,000 acres. Beyond this, beginning at about 50 miles from the coast, is a broad undulating middle portion, six hundred to a thousand feet above sea level, covered with pitch-pine. This region is of exceptional healthfulness, particularly with regard to pulmonary consumption. The pine-forest region gardually rises into, but is lost in Western North Carolina, no part of which is less than 1,500 feet above the level of the sea, and where the Alleghanies reach their greatest altitude, and the loftiest peaks east of the Mississippi

River. The range nearest the coast is the Blue Ridge, while the succeeding groups are known as the Black, Smoky, Iron, and Unaka Mountains. The lowest points or gaps in the Black Mountains are nearly as elevated as Mount Washington, while Mount Mitchell, according to the measurement of Prof. Guyot, is 400 feet higher, or 6,707 feet above the level of the sea. The table land, or mountain-plateau between the ridges consists of a series of well-watered forest-covered or fruitful valleys and hills, from 2,000 to 3,000 feet above the level of the sea, and is one of the most picturesque and salubrious sections in the United States. The average annual rain-fall in this region is about 44 inches. In the tide water region it is from two to four inches more. The mean temperature at Ashville (2,250 feet above the level of the sea) is 48° to 50°. At Raleigh, 60°; Wilmington, 63.1°; Smithville, mouth of Cape Fear River, 64.13.°

The mineral springs of North Carolina of best repute are the *Warm* and *Hot Springs* of Buncombe County, in the northwest part of the State, on the western branch of the French Broad River—a beautiful and romantic region embosomed in lofty mountains. There are several springs, varying in temperature from 94° to 104°. Analysis of the water by Professor E. D. Smith (*Silliman's Journal*, vol. viii.) gives the following results :—

Muriate of lime and magnesia, ...	4	grains.
Sulphate of magnesia, ...	6	"
Sulphate of lime, ...	14.05	"
Insoluble residue, ...	2.05	"
Loss, ...	1	"
	27.10	"

Equal to 4.66 grains solids in a pint.

Shocco Springs, in Warren County, nine miles from Warrington, are the saline-sulphur class, and aperient in their effects. "*Jones' White Sulphur and Chalybeate Springs*," nine miles distant from the Shocco; and *Kittrell's Springs*, in Granville County, on the Welden railroad to Raleigh, half a mile from Henderson, possess considerable local reputation for alterative and tonic effects, but no analyses have been furnished.

In the very heart of the pine forest and sandy soil region, near Manly, there are also several chalybeate springs and one at least sulphurous, of evident value, but no reliable analysis of these waters has yet been made.

In Virginia, the mountainous region is more expanded; there is a greater variety of surface, and consequently a somewhat more varied climate. The mean annual temperature in the State ranges from 60° to 64° in the southeastern part of the State to 48° to 52° in the valley and mountains. The annual range from the lowest temperature in winter to the highest in summer is about 86°.

The following table represents the temperature and rain-fall at nine

different places of observation in Virginia, compiled from Hotchkiss' *Summary* and the Signal Service reports :

METEOROLOGICAL DATA.	Johnstown, lat. 37° 23', lon. 75° 55'; elevation about 50 feet.	Hampton, lat. 37° 01', lon. 76° 21; elevation 55 feet.	Zuni, lat. 36° 53', lon. 76° 51'; elevation about 70 feet.	Comom, lat. 38° 55', lon. 77° 18'; elevation about 75 feet.	Vienna, 38° 55', lon. 77° 17' 38"; elevation 125 feet.	Lynchburg, lat. 37° 30', lon. 79° 02'; elevation, 575 feet.	Staunton, lat. 38° 10', lon. 79° 4'; elevation, 1,400 feet.	Lexington, lat. 37° 41', lon. 79° 25'; elevation, about 925 feet.	Wytheville, lat. 36° 55', lon. 81°; elevation, 2,300 feet.
TEMPERATURE.	°	°	°	°	°	°	°	°	°
Mean temperature of year ..	57.1	58.5	59.5	56.8	55.9	57.3	53.6	56.5	53.8
Highest " " ..	95	100	104	104	93	95	93	104	95
Lowest " " ..	9	6	−4	6	8	9	5	−3	−4
Range of annual temperature of year....................	86	94	108	98	85	86	88	107	99
Mean temperature of spring..	52.4	54.7	57.1	54.1	54.2	55.6	51.3	54.8	51
Highest " " ..	87	96	96	92	86	84	84	92	85
Lowest " " ..	18	18	19	17	23	18	14	17	-1
Range " " ..	69	78	77	75	63	66	70	75	86
Mean temperature of summer	76.3	78.6	81.2	77.3	75.4	76.1	73.7	77.1	71.5
Highest " " ..	95	100	104	104	93	95	93	104	95
Lowest " " ..	57	60	60	52	57	55	56	52	49
Range " " ..	38	40	44	52	36	40	27	52	46
Mean temperature of autumn	58.4	58.9	55.3	57.8	57.8	57.1	52.8	53.5	50.9
Highest " " ..	90	92	91	86	86	82	82	90	82
Lowest " " ..	27	25	20	28	27	29	28	18	18
Range " " ..	63	67	71	58	59	53	54	72	64
Mean temperature of winter..	41.3	44.7	44.6	38.2	36.5	41.3	37	40.7	35.6
Highest " " ..	74	78	74	72	69	66	69	74	62
Lowest " " ..	9	6	−4	6	8	9	5	−3	−4
Range " " ..	65	72	78	66	61	57	64	77	66
RAIN-FALL.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Annual amount..............	33.16	40.15	42.97	29.27	48.51	44.74	41.99	48.58	35.10
Rain-fall of spring...........	10.69	11.35	14.81	7.81	13.90	11.62	12.15	12.77	8.95
" " summer.........	7.45	12.60	8.80	7.32	13.90	14.30	8.78	8.25	11.05
" " autumn.........	6.75	6.80	8.52	8.68	9.51	9.16	11.49	15.25	7.08
" " winter..........	8.27	9.40	10.84	5.46	11.20	9.66	9.57	12.23	8.02

From Old Point Comfort, Virginia, Surgeons G. E. Cooper and I. E. Simmons, U. S. Army, on four years' observation at Fort Monroe [1] report the climate of this place comparatively mild. The winters are open and the thermometer, except in extremely rare instances, does not fall below 12° F. The duration of the cold period seldom passes seventy-two hours, when the cold snap gives way and the mercury indicates an

[1] "Report on the Hygiene of the U. S. Army." Circular No. 8, p. 51.

increase of temperature. The cold, however, is felt more perceptibly than in those regions where it is continuous, and the system is far more susceptible to the influence of a decrease of temperature than it is in the more northern latitudes. . . .

"The prevailing winds of spring and summer are southeast and southwest; those of fall and winter east, northeast, and northwest. The easterly winds are the most severe in February and March, and with them come diseases of the throat and lungs to both adults and infants. With the latter, croup is most common in February and early March, when the winds, chilled by the icebergs on the banks, continue blowing from the northeast for several successive days. . .

"Prior to the war of secession, there was but little, if any, malarial disease, originating at Old Point Comfort proper, met with; and Fort Monroe was regarded as one of the few places in the tidal-water region of Virginia exempt from its influence. So highly was the sanitary condition regarded, that it became the great watering-place of the southern states. Pleasure-seekers in great numbers congregated here during the summer months to enjoy the salt-water bathing; and many invalids, who had been suffering from the effects of malarial cachexia, came to Old Point Comfort to recuperate their health by the tonic sea-breezes, and at the same time remove themselves from the depressing influences of the fever poison to which, at their homes, they had been subjected. Now, however, the sanitary status has changed, and malarial disease is quite common here. There is no doubt of its being contracted, not only on the point, but within the walls of the fort. Formerly the few cases of malarial fever occurred in men who had been on picket-guard at Mill-Creek Bridge, or in those who, going on leave, would get drunk, and sleeping out during the night, expose themselves to the malarial exhalations on the mainland. To what this change is attributable is not certain. Two hypotheses are, with claims of reason, advanced. Before the war occurred, the lands under cultivation were well-drained and well cared for. They had been worked for a long time and could not be regarded as fresh soil, the upturning of which is always productive of malarial disease in the southern States; much of the country, too, was covered with virgin forests of pine, oak, and hickory, extending for a short distance north and west of Mill Creek to Back River, thus intercepting, to a great extent, the winds impregnated with malarial exhalations which came from over the swamplands in its vicinity. This Back River is the receptacle of the waters of many small streams and creeks which head in the swamp-lands, and find their way through it into Chesapeake Bay at a distance of about a league to the north of the fort. The lands proximate to these creeks are swampy for the greater part, the waters upon them being only brackish. These swamps, when the tides are low, and the rains heavy, as is often the case in late summer and early autumn, become stagnant fresh-water marshes, and furnish all

the material necessary for the production of southern autumnal fevers. On the banks of, and in all the country near to Bock River, malarial fevers have full sway during the greater portion of the year, and in the autumn, when not promptly and skilfully treated, are very destructive to life, as in many cases they assume the malignant type, here called congestive remittent, corresponding to the disease so admirably described by Professor George B. Wood, in his work on the Practice of Medicine, under the name of pernicious fever. . . .

"During the war, the greater part of the forest to the northwest of the fort was cut down, thus giving free scope to the winds blowing over the marshes of Black River. Much, too, of the virgin land formerly covered by forest has been turned up for cultivation. The cultivated land, too, which was lying fallow during the five years of the war, is once more being worked, poorly, it is true, for the drains are all filled up or choked, and the owners, wanting as they are in labor or the means of procuring it, cannot put them in proper order. The result of this want of proper drainage is that the rains collect upon the lowlands, to be removed only by solar evaporation. . . .

"The other hypothesis—more probably the correct one, so far as the production of malarial disease inside the fort is concerned—that large quantities of clay and soil have been brought into and around the fort for the purposes of repairing and filling up the roads inside and outside of the same, as well as for repairing portions of the work. This clay and soil were procured and brought from the west side of Mill Creek, in the locality where malarial fevers are most common. Prior to the spreading of this clay upon the roads, there were few, if any, fevers of a malarial type originating in the fort: but in a very short time afterwards they presented themselves for medical treatment. Previous to this the young children who went not outside of the walls in the night or in the early morning, did not suffer from malarial disease, but since then, children who seldom go outside the fort, and never off the Point, are attacked with both remittent and intermittent fever. In addition to fevers of a malarial origin, diarrhœas and dysenteries are frequently met with, caused either by irritating ingesta, or showing symptoms and complications of malarial disease. Indeed, there is scarcely any disease of importance presented for treatment which does not in its course give indications of malarial complications, and which does not require for its treatment antiperiodics of some kind or other. In early summer, which is generally hot and humid, there is much derangement of the hepatic secretions, at times excessive, producing diarrhœas; at others diminished, running oftentimes into jaundice. These conditions, if not promptly relieved, seem to be but the precursors of remittent fevers, more or less severe. The locality is unfavorable to those affected with diseases of the lungs."

The mineral springs of Virginia and West Virginia are of almost

every variety, and some of them of world-wide repute; comprising various and different compounds of *sulphur, chalybeate,* simple and compound; *acidulous* or *carbonated; saline; aluminated chalybeate,* and *thermal waters.*

The *White* Sulphur Springs are in Greenbrier county, West Va., on Howard's Creek, in the midst of a beautiful and picturesque valley, about six miles from the Alleghany ridge, which separates the waters that flow into the Chesapeake Bay from those which flow into the tributaries of the Mississippi River.

According to analysis of Prof. W. B. Rodgers, one pint of this water at 62° F. contains—

Solids.	Grains.
Carbonate of magnesia,	0.146
Carbonate of lime,	0.441
Chloride of sodium,	0.065
Chloride of magnesium,	0.020
Chloride of calcium,	0.003
Sulphate of soda,	1.169
Sulphate of magnesia,	2.370
Sulphate of lime,	9.148
Sulphate of alumina,	0.003
Protosulphate of iron,	0.019
Earthy phosphates,	trace
Iodine (combined with sodium or magnesium),	undetermined
Organic matter,	0.001
	13.394

Gases.	Cubic inches.
Carbonic gas,	1.06
Sulphuretted hydrogen,	0.37
Oxygen,	0.05
Nitrogen,	0.54

Flow thirty gallons per minute.

Thirty-five miles to the north of the White Sulphur are the famous *Warm* Springs, in the midst of a region described as follows by Prof. J. L. Cabell, of the University of Virginia.

"The Hot Springs" and two other thermal watering-places, long and favorably known to the citizens of Virginia as summer resorts, namely, the "Warm Springs" and the "Healing Springs," are in a narrow valley between two mountain ranges which run parallel to each other from northeast to southwest in the County of Bath. This county extends from the western limits of Augusta County to the Alleghany Mountains, which is here the boundary between Old and West Virginia. This county is very mountainous and broken, and is well watered by the Jackson and the Cow Pasture Rivers and their numerous tributaries. Shortly beyond the southern border of the county, these two rivers unite near Clifton Forge, in Alleghany County, to form the James River.

Within the limits of the county, they skirt the base of the mountains on one or both sides, but elsewhere considerable tracts of alluvial flats intervene, and these constitute a large part of the most valuable arable land of the county, though in many places, not only the subordinate valleys, but the sides of the mountains for a considerable distance from their base are susceptible of remunerative tillage. Among these subordinate valleys, that which derives its popular name of "The Warm Springs Valley," from the numerous thermal sources which it affords, is much the most remarkable. It is bounded on the east by "The Warm Springs Mountain," which extends for a distance of more than thirty miles in a straight direction and without a gap, while, on the west, the mountain barrier is a deeply serrated ridge; the gaps, which are found at short distances apart, extending quite to the foot of the ridge, and presenting extremely picturesque gorges, barely, in some places, wide enough for the passage of a creek and a narrow road-bed which frequently crosses the winding stream, according the exigences of the situation. These creeks, having watered the valleys into which their waters descend from the mountain sides, find thus a ready outlet by these numerous gorges into the larger valley of Jackson River. This somewhat peculiar topographical feature insures a perfection of drainage and of ventilation not often attainable in narrow valleys surrounded by lofty mountains, which exclude the sun's rays for a large part of the day, and oppose insurmountable barriers to the ready escape of the waters by surface drainage.

"The Hot Springs lie at the head of one of these intersecting gorges, and the stream (Cedar Creek) which results from the united body of their waters rushes down the steep declivity of the gorge, so as to clear the main valley within a few feet from their sources. Through this western gap the rays of the evening sun brighten the settlement long after its disk has sunk behind the mountain in other parts of the valley. Twelve or fifteen miles from the Hot Springs, the valley terminates abruptly by merging into that of Jackson River, but at an elevation of about two hundred feet above the latter; and just here the Falling Springs Creek, descending from the Warm Springs Mountain on the east, crosses the road, and then presents the picturesque spectacle of an unbroken fall from the top of the precipice to the valley beneath. This miniature cataract, miniature as to breadth and volume of water, is half as high again as that of Niagara, and was considered by Mr. Jefferson worthy of being mentioned and described in his "Notes on Virginia."

"The average elevation of the valley above the sea-level may be stated to be about 1,600 feet, and that of the mountain ridge at least 2,500 feet. The mountain is of white sandstone, but the rocks of the valley are chiefly limestone, and the calcareous soil abounds in caverns. The springs for the most part contain a notable amount of carbonate and a small quantity of sulphate of lime; but those which issue from the moun-

tain sides a short distance above their base have no calcareous matter, or so little as not to be sensibly affected by the ammonium oxalate test. Their water is pure and sparkling, and it has accordingly been utilized for drinking and cooking purposes as a substitute for the more highly mineralized water of the valley. Similar arrangements for the water-supply exist at the Warm Springs, five miles north, and at the Healing Springs, three miles south of the Hot Springs.

"Capt. J. A. August, the intelligent manager of the Hot Springs, informs me that the temperature on the three *hottest* days of the last summer was as follows:

July 18th, 1875,	at 6 A.M., 78° F.;	at 12 M., 84°;	at 6 P.M., 85°.
Aug. 18th,	" " " 70° F.;	" " 76°;	" " 72°.
Sept. 4th,	" " " 70° F.;	" " 77°;	" " 74°.

"The mean temperature for the three summer months registered at the three specified hours was 66°. After nine o'clock at night, or often earlier, there is a depression of several degrees, but no record has been kept of the minimum night temperature. More frequently than otherwise, blankets are required, even by persons in strong health.

"Dr. B. F. Hopkins, who has practised medicine in this valley for twelve years, reports that no epidemics have occurred in all that time. There is absolutely no malaria. He treated a few sporadic cases of typhoid fever; and in cold and damp weather in early spring those who expose themselves carelessly may contract pneumonia or pleurisy, but even these diseases are not common, and the doctor would not make his living, although his practice ranges over a length of fifty miles, if it were not for the obstetrical cases.

"The frosts of the latter part of September generally cause a sudden emigration of the visitors, only to encounter the as yet unabated heat, and the malaria of the lower country. Moreover, they lose some of the greatest attractions of mountain climate and scenery. The nights and early mornings are sharply cold, but are made highly enjoyable by blankets for the bed and by wood fire in open chimneys, while the outdoor temperature before and after noon is inexpressibly delicious. Add to this the exquisite beauty of the forests, whose foliage does not fall into the sere and yellow leaf, as occurs in the lowlands, but with the first early frosts presents infinite varieties and shades of bright colors, which cause the mountain sides to resemble the most beautiful of flower gardens of immense extent and colossal size; and it will readily be seen that health-seekers, who are also lovers of nature, will find both profit and enjoyment in prolonging their stay until the first days of October. This, I believe, has been the uniform testimony of all who have made the experiment."[1]

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[1] The Sanitarian, vol. iv., pp. 253–4.

Analysis of the Hot Springs.[1]

One pint contains	Ladies' Boiler Bath, 110° Fahr. Col. Wm. Gilman.	Ladies' Sulphur Bath. 102° Fahr. Col. Wm. Gilman.	Gentlemen's Pleasant Bath, 78° Fah. Col. Wm. Gilman.
SOLIDS.	Grains.	Grains.	Grains.
Carbonate of magnesia.......	0.335	0.350	0.252
Carbonate of iron (protoxide)..	0.014	0.008	0.010
Carbonate of lime.............	2 168	2.055	1.185
Carbonate of potassium	0.200	2.021	0.020
Chloride of sodium...........	0.015	0.017	0.016
Sulphate of potassa.	0.168	0.228	0.071
Sulphate of soda	0.128	0.126	0.106
Sulphate of magnesia	0.707	0.638	0.133
Sulphate of lime.........	0.217	0.263	0.378
Silica.........................	0.218	0.171	0.086
Total....	4.170	3.877	2.257

Within an area of thirty-five miles are also the "Sweet," "Salt," "Red," and "Blue" springs, of various temperatures and other properties, some of them containing large quantities of gas; *chalybeate* springs of various strength, the Rockbridge *Alum* Springs, and the *Salt-Sulphur Iodine* Spring.

There are several alum springs of various strength in combination with other salts. According to analysis by Professor Aug. Hayes, given by Moorman, "*Rockbridge,* No. 1, a standard gallon at 60° F. contains:

Of bases:	Sodium and soda, . . .	0.250
	Potash, ...	traces.
	Ammonia, ...	0.471
	Lime, ...	0.594
	Magnesia, ...	0.368
	Alumina, ...	4 420
	Protoxide of iron, . . .	1.748
Of acids:	Sulphuric acid, . . .	32.626
	Carbonic "	2.623
	Organic " . . .	0.930
	Silicic "	2.460
	Chlorine " . . .	0.257

"The changes which take place in these waters by boiling, the action of sulphuric acid and salts of silver, indicate that these proximate constituents are combined to form the following salts:

Sulphate of lime, ...	1.439
Sulphate of magnesia, ...	1.081
Protoxide of iron, ...	3.683

[1] Walton's "Mineral Springs of the United States and Canada," p. 317.

Alumina,	14.764
Chloride of sodium,	0.423
Silicate of soda,	2.544
Crenate of ammonia,	1.401
Free sulphuric acid,	18.789
Free carbonic acid,	2.623
	46.747
Pure water,	58,325.000
	58,372.000 [1]

The same author gives the following analysis by Dr. David Stuart, of Baltimore, of the water of the *Salt Sulphur* Iodine Spring:

GASES.	Cubic inches.
Sulphuretted hydrogen,	19.19
Carbonic acid,	34.60
Oxygen,	00.62
Nitrogen,	04.73
	59.14

SOLID CONTENTS OF ONE GALLON.

SOLIDS.	Grains.
Sulphate of magnesia,	20.00
Sulphate of soda,	24.00
Carbonate of lime,	33.00
Carbonate of magnesia,	07.00
Chloride of magnesium,	00.28
Chloride of sodium,	01.28
Chloride of calcium,	00.56
Silicic acid,	01.76
Carbonate of potash,	02.33
Carbonate of soda,	10.80
Sulphate of lime,	68.00
Iodine,	00.93
Bromine,	00.65
Sesquioxide of iron,	01.06
Alumina,	00.18
Phosphate of soda and lithia,	00.73
Total solids,	172.48

Specific gravity 1002.7; reaction alkaline; temperature, 64.75° to 65.50°.

The Bath or Berkley Warm Springs, in the town of Bath, Morgan County, two miles and a half from Sir John's Depot, on the Baltimore and Ohio Railroad, one hundred and thirty miles west from Baltimore, and *Shannondale* (*saline chalybeate*) Springs, in Jefferson County, in a

[1] "Mineral Waters of the United States and Canada." By J. J. Moorman, M.D., etc. P. 271–72.

peninsula of the Shenandoah River, known as the "Horse Shoe," are also celebrated as among the best proven waters of their kind, and with excellent surroundings. Such are among the most celebrated of the Virginia springs; but there are many others probably of equally good qualities, a catalogue and analysis of the waters of which would alone fill several pages, all situated in a region no less remarkable for its rare salubrity than for the great number and various qualities of the mineral waters.

In the low-lying and swampy area between the tide-water and the highlands, in some places a hundred miles or more wide, and along the shores and valleys of the bays and rivers, all the way from Georgia to New Jersey, in the summer and autumn especially the climate is insalubrious, and malarial diseases are more or less prevalent.

There are a number of seaside and island resorts along this region, however, with sandy soil, which, in the summer season, when the prevailing winds are southerly, are exceptions. Thus situated and exposed, with proper local sanitary conditions the climate approximates an ocean atmosphere and its advantages.

Moreover, on some of the miniature plateaus covered with forest trees, in New Jersey, such, for example, as Schooley's Mountain, twelve hundred feet above the level of the sea, within a few hours' ride from New York and Philadelphia, climatic advantages obtain superior to many which are sought at thousands of miles more distant.

Schooley's Mountain Spring, in Morris County, N. J., is of old and good repute "as a pure carbonated chalybeate." It is situated in the midst of a very salubrious region, eleven hundred feet above the level of the sea, two and a half miles by stage from Sackett's Town, on the Delaware and Lackawanna Railroad, fifty miles from New York.

One pint contains (C. McIntire, Jr.):

Solids.	Grains.
Carbonate of soda,	0.072
Carbonate of magnesia,	0.200
Carbonate of iron,	0.072
Carbonate of manganese,	trace
Carbonate of sodium,	0.054
Carbonate of lime,	0.178
Sulphate of lime,	0.210
Alumina,	0.018
Ammonia,	trace
Silicic acid,	0.092
Chloride of sodium,	0.054
Total,	0.896

Carbonic acid gas considerable, but not determined. Temperature 50°. Flow, 30 gallons per hour.

Bedford Springs, in Bedford County, Penn., have long been noted as among the most valuable *purgative chalybeate* waters, said to possess properties very similar to the celebrated springs of Franzenbad, in Bohemia.

One pint contains (58° F., Dr. Church):

Solids.	Grains.
Carbonate of iron,	0.625
Carbonate of lime,	1.000
Chloride of sodium,	1.250
Chloride of lime,	0.375
Sulphate of magnesia,	10.000
Sulphate of lime,	1.875
Loss,	0.375
Total,	15.500
Gas.	Cubic inches.
Carbonic acid,	9.25

Gettysburg Spring, Gettysburg, Adams County, Pa., has attracted considerable attention in recent years as an *alkaline calcic* or "*Katalysine*" water. According to analysis by Prof. F. A. Genth, one pint contains:

Solids.	Grains.
Carbonate of soda,	0 027
Carbonate of magnesia,	0.041
Carbonate of iron,	0.003
Carbonate of manganese,	0.001
Carbonate of lime,	0.627
Chloride of sodium,	0.082
Chloride of lithium,	trace
Sulphate of potassa,	0.026
Sulphate of soda,	0 308
Sulphate of magnesia,	0.847
Sulphate of lime,	0.104
Phosphate of lime,	0.001
Fluoride of calcium,	0.001
Borate of magnesia,	0.004
Silicic acid,	0.254
Organic matter with trace of nitric acid, etc.,	0.088
Impurities suspended in the water, like clay, etc.,	0.138
Total,	2.554

In addition, traces of carbonate of copper, sulphate of strontia, carbonate of nickel, carbonate of cobalt, and sulphate of baryta.

The *Minnequa* Springs, in Bradford County, Pa., on the Northern Central Railroad, thirty-six miles south of Elmira, and *Carlisle* Springs, Cumberland County, Pa., are sulphur waters. *Cresson* Springs, at Cresson, in Cambria County, a station on the Pennsylvania Central

Railroad; *Fayette* Springs, in Fayette County; and *Blassburg* Springs, are *chalybeate*, delightfully situated in the Laurel Mountains, among the most romantic scenery in Pennsylvania.

North of the 40th parellel, in Pennsylvania, in the higher ridges of the Alleghanies, there is a more considerable increase of the rain-fall than on the plains, as compared with the more southern portion of the range; and there are two or three considerable areas or plateaus from twelve hundred to fifteen hundred feet above the sea level, with a slight increase of humidity; but in these localities, as in those further south, the surface conditions are such as to exercise but little or no influence on the temperature. It is less only in proportion to altitude, one degree for about every four hundred feet.

Further north, in New York, Vermont, and New Hampshire, the altitude again increases, but with less characteristic ridges and valleys. There are several groups of mountains, and small plateaus of from fifteen hundred to two thousand feet elevation, and especially in the Adirondacks, notable for their equability of temperature, characteristic of forest regions, and of good repute as an all-the-year-round resort for consumptives.

Some of the summits of the Adirondacks, and even of the more elevated peaks of the Catskills, at some seasons, are obscured by clouds, and have more cloudy weather than the table lands below; but the difference in the amount of actual precipitation, so far as it has been measured, is too slight for any observable effect upon the salubrity of the atmosphere. It is probably more apparent than real, on account of the snowfall in, and the conservative effects of, the forests as compared with the rain-fall over less sheltered areas.

Mount Washington, 6,800 feet elevation, is exceptional. Violent gusts of wind, hail, or snow, are of almost daily occurrence at its summit, even in summer; while the atmosphere 4,000 feet below is clear and equable. And Mount Marcy, in the Adirondacks, 5,370 feet altitude, is more or less subject to the same conditions.

The atmosphere of the valleys of Lake Ontario and Lake Champlain is said to be, by some persons who profess to be capable of judging by their sensations, dryer than that of the adjacent highlands. But there are no records to prove it. And it is altogether probable that, in the summer season especially, when the alleged difference is said to be the most marked, the evaporation from the surface of the lakes imparts an amount of humidity to the atmosphere thereabouts which fully compensates for any apparent deficiency from rain-fall.

Next to Virginia, New York is more distinguished for the number and variety of mineral springs than any State in the Union. Moreover, the chief of them are in one group—the Saratoga—as in Virginia, except that the area is much less extensive.

Saratoga Springs are in Saratoga County, N. Y., thirty-seven miles

Analysis of Saratoga Springs.

One pint contains.	High Rock, 52° F. Prof. C. F. Chandler.	Congress, 52° F. Prof. C. F. Chandler.	Hathorn. Prof. C. F. Chandler.	Empire. Prof. C. F. Chandler.	Columbian. J. H. Steele, M.D.	Pavilion. Prof. C. F. Chandler.	United States. Prof. C. F. Chandler.	Seltzer, 50° F. Prof. C. F. Chandler.	Geyser, 46° F. Prof. C. F. Chandler.	Star, 52° F. Prof. C. F. Chandler.	Red Spring. Prof. J. H. Appleton.	Eureka. R. L. Allen, M.D.	Excelsior. R. L. Allen, M.D.	Hamilton. R. L. Allen, M.D.	Crystal, 50° F. Prof. C. F. Chandler.
SOLIDS.	Grains.	Grains.	Grains.	Grains.	Grains	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.	Grains.
Carbonate of soda	3.029	0.934	0.372	0.782	1.336	0.327	0.405	2.552	6.175	1.097	1.107	0.625	1.875	4.281	1.212
Carbonate of magnesia	4.069	9.019	13.072	3.182	3.461	3.650	5.399	2.988	10.322	4.586	2.618	3.667	4.042	4.883	5.568
Carbonate of iron	0.135	0.031	0.101	0.079	0.698	0.233	0.065	0.155	0.089	0.110	......	0.375	0.402	0.578	0.185
Carbonate of lime	11.473	12.449	14.815	9.520	8.500	10.432	8.084	7.804	14.793	10.795	7.324	5.165	9.625	12.249	8.845
Carbonate of lithia	0.154	0.374	......	0.163	......	0.744	0.380	0.071	0.549	0.124	0.016	....	......	......	0.339
Carbonate of strontia	Trace.	Trace.	Trace.	Trace.	.....	Trace.	0.001	Trace.	0.041	Trace.	......	......	......	.....	Trace.
Carbonate of baryta	0.050	0.095	0.178	0.008	......	0.090	0.094	Trace.	0.206	0.010	......	......	......	......	0.074
Chloride of potassium	1.122	1.006	1.199	0.536	......	0.958	1.078	0.167	3.079	1.212	0.686	......	......	......	1.040
Chloride of sodium	48.766	50.055	63.746	63.328	33.375	57.489	17.734	16.786	70.260	49.795	8.699	20.852	46.330	37.332	42.058
Sulphate of potassa	0.201	0.111	Trace.	0.346	......	0.254	......	0.069	Trace.	0.675	......	......	......	......	0.269
Sulphate of soda	......	......	......	......	......	......	......	......	......	......	......	......	0.165	......	......
Sulphate of magnesia	......	......	......	......	......	......	......	......	......	......	......	0.268	......	......	......
Phosphate of soda	Trace.	0.002	0.001	0.003	......	0.001	0.002	Trace.	Trace.	Trace.	Trace.	......	......	......	0.001
Phosphate of lime	......	......	......	......	......	......	......	......	......	......	Trace.	......	......	......	......
Iodide of sodium	0.011	0.017	0.025	0.001	0.320	0.009	0.006	0.004	0.031	0.015	......	0.583	0.529	0.449	0.008
Bromide of sodium	0.091	0.069	0.192	0.033	......	0.123	0.106	0.079	0.276	0.071	......	0.196	......	......	0.051
Fluoride of calcium	Trace.	Trace.	Trace	Trace.	......	Trace.	Trace.	Trace.	Trace.	......	......	......	......	......	Trace.
Biborate of soda	Trace.	Trace.	......	Trace.	......	Trace.	Trace.	Trace.	Trace.	Trace.	......	......	......	......	Trace.
Alumina	0.153	Trace.	0.116	0.0052	......	0.041	0.012	0.047	Trace.	Trace.	[1]0.219	0.029	......	......	0.038
Silicate of potassa	......	.....	......	......	......	......	......	......	......	......	......	......	0.875	......	......
Silicate of soda	......	......	......	......	......	......	......	......	......	......	......	......	0.500	......	......
Silica	0.283	0.105	0.157	0.182	0.256	0.394	0.398	0.320	0.013	0.160	0.339	0.067	......	[2]0.125	0.401
Organic matter	Trace.	Trace.	Trace.	Trace.	......	Trace.	Trace.	Trace.	Trace.	Trace.	......	.....	......	......	Trace.
Total	69.502	75.267	93.874	78.215	47.946	76.945	33.764	31.042	105.834	68.650	21.008	31.827	64.343	59.897	60.089
GAS.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.	Cub. in.
Carbonic acid	51 (1856)	49 (1871)	47	43 (1872)	34	41	30	40	57 (1870)	50	..	29	31	40	39 (1870)

[1] Alumina and sesquioxide of iron.

[2] Silica and alumina.

north of Albany, via Rensselaer and Saratoga Railroad. From the north, by the way of Lake Champlain and railroad from Whitehall to Saratoga, forty-one miles. The hotels and other appointments at Saratoga and the Springs are unsurpassed. The preceding tabulated arrangement of the analyses of the waters is extracted from the excellent work of Walton, before cited.

At Ballston, also in Saratoga County, twenty-six miles north from Albany, the United States, Ballston Artesian Lithian Well, Franklin Artesian Well, and Conde Dentonian Well are saline springs of the same general character as those of Saratoga. They contain a large amount of carbonic acid, and are heavily impregnated with chloride of sodium.

Sulphurous springs also abound in New York, and several of them are of great celebrity. Some are in the region already referred to—Saratoga County—but to these much less attention has been given than to the others. Among the most noted are *Sharon, Richfield, Avon, Clifton, Massena,* and *Chittenango. Cherry Valley, Longmuirs* (Rochester), *Columbia* (near Hudson), *White Sulphur* (Cairo, near Catskill, Greene County), and *Dryden* (Tompkins County), are also springs of considerable local repute for such affections as are commonly benefited by sulphurous waters.

Analysis.

Sharon Springs.

One pint contains.	White Sulphur, 48° F. J. R. Chilton, M.D	Red Sulphur, 48° F. Prof. L. Reed.	Gardner Magnesia, 48° F. Prof. L. Reed.
Solids.	Grains.	Grains.	Grains.
Carbonate of soda	......	0.043	0.042
Carbonate of magnesia	......	0.051	0.100
Carbonate of lime	.....	1.122	0.842
Chloride of sodium	0.28	0.041	0.154
Chloride of magnesium	.30	0.091	0.054
Chloride of lime	......	0.008	0.020
Sulphate of magnesia	5.30	2.370	2.460
Sulphate of lime	13.95	12.080	11.687
Hydrosulphuret of sodium and hydrosulphuret of calcium.	0.28	......	......
Hydrosulphuret of calcium and magnesium.	......	0.111	0.781
Silicic acid	......	0.056	0.050
Total	20.11	15.973	16.190
Gases.	Cubic inches.	Cubic inches.	Cubic inches.
Carbonic	......	0.57	0.277
Sulphuretted hydrogen	2.	1.31	0.750
Atmospheric air	......	0.50	0.375
Total	2.	2.38	1.402

Richfield Springs.

One pint contains (Prof. Reid):

SOLIDS.	Grains.
Carbonate of magnesia,	1.480
Carbonate of lime,	0.870
Chlorides of sodium and magnesium,	0.187
Sulphate of magnesia,	3.750
Sulphate of lime,	2.500
Hydrosulphate of magnesia and lime,	0.250
Undetermined,	19.187
Total,	28.224
GAS.	Cubic in.
Sulphuretted hydrogen,	3.3

Avon Springs.

One pint contains.	Upper Spring, 51° F. Prof. Hadley.	Lower Spring. J. B. Chilton, M.D.	New Batte Spring 51° F. Prof. Beck.
SOLIDS.	Grains.	Grains.	Grains.
Carbonate of lime	1.000	3.666	4.370
Chloride of sodium	2.300	......	0.710
Chloride of calcium	.....	1.051	......
Sulphate of soda	2.002	1.716	4.840
Sulphate of magnesia	1.250	6.201	1.010
Sulphate of lime	10.500	7.180	0.440
Iodide of sodium	......	Trace.	...
Total	17.500	19.814	10.370
GASES.	Cubic inches.	Cubic inches.	Cubic inches.
Carbonic acid	0.70	0.49	..... .
Sulphuretted hydrogen	1.50	1.25	.050

The climate of New England, as may be seen by reference to the tables and charts on other pages, is severe and subject to great extremes; but on the high ground of the interior it is generally healthy. The fogs and easterly winds on the sea coast are said to promote consumption, but it is not a little remarkable that the highest rate of mortality from this cause is in Vermont, which is devoid of sea coast.

On the sea coast of Maine snow lies on the ground from three and a half to five months yearly, and in the interior a month longer. The summers are consequently very short and hot. At Brunswick, in fifty-two years' observation, July was the only month in the year in which no frost occurred.

The mean annual temperature observed at Bowdoin College, Brunswick, for a series of fifty-two years, was 44.40°; maximum, 102°; minimum, 30°, and annual range 125°.

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Chittenango Springs.

One pint contains.	White Sulphur, 49° F. Prof. C. F. Chandler.	Cave Spring, 49° F. Prof. C. F. Chandler.	Magnesia, 49° F. Prof. C. F. Chandler.
SOLIDS.	Grains.	Grains.	Grains.
Carbonate of magnesia	1.631	1.776	1.439
Carbonate of iron	0.007	0.014	0.029
Chloride of potassium	0.019	0.029	0.041
Chloride of sodium	0.129	0.196	0.229
Chloride of lithium	Trace.	Trace.	Trace.
Sulphate of soda	0.027	......	......
Sulphate of magnesia	0.244	0.948	1.589
Sulphate of lime	10.177	13.265	14.835
Sulphate of strontia	Trace.	Trace.	Trace.
Hydrosulphate of sodium	0.014	0.043	0.094
Hydrosulphate of calcium	......	0.140	0.116
Hypophosphite of soda	......	0.032	0.002
Alumina	0.010	0.027	Trace.
Silica	0.035	0.064	0.072
Total	12.293	16.534	17.996
GASES.	Cubic inches.	Cubic inches.	Cubic inches.
Carbonic acid	4.5	3.2	2.3
Sulphuretted hydrogen	0.1	0.4	1.6

New Hampshire, owing to the general elevation of the State, is somewhat colder in the same latitude than Maine. The highest temperature observed for a series of years in this State was 98°; the lowest 30°, and the range 120°.

In Vermont, the climate is also marked by great extremes: the winters are cold and long; the summers short, but frequently for a few days at a time exceedingly hot. The mean annual temperature is 40°; the average maximum, 91°; average minimum, 28°; and annual average range 120°.

Rhode Island, by reason of a somewhat insular position, has a slightly milder climate than the adjacent States. The mean annual temperature of the State ranges from 47° to 51°. The average mean of Providence, 49.94°, and the average annual range seldom exceeds 100°. Of Newport, Surgeons J. F. Head and John Campbell, U. S. Army, in their official report of four years' observations at Fort Adams,[1] observe:

"The climate of the southern part of this island is, in some respects, an exception to that of the region in which it is classed. Its peculiarities, which, with the facilities for sea-bathing, have made Newport a summer resort, are due to its insular position, its general slope toward the south, and doubtless to the nearness of the western edge of the Gulf

[1] Op. cit., p. 5.

Stream. The winter temperature is much milder than that of Providence, and the summers are remarkably cool and equable. The same cause, however, which produces these results occasions, in spring and early summer, the heavy fogs for which this vicinity is famous. The influence of the dampness upon the health of the inhabitants is less unfavorable than might reasonably be expected."

Dr. H. R. Storer, of Newport, has also remarked upon the special advantages of Newport as a "winter resort for consumptives," on account of its insular position.[1] He cites statistics which show that in a summary of the mortality from consumption in twenty-five towns in Massachusetts, chiefly inland, where there was the least mortality, 2.25 per cent of the inhabitants, for a period of ten years—1856–65—the rate in Newport was only a little more than half as large, 1.53 per cent. And in comparing the effects of the moist atmosphere of Newport with that of soil moisture, he quotes from a paper on the Isle of Shoals, off the New Hampshire shore, by Dr. H. I. Bowditch, who states: "I am certain that, in many cases of early phthisis, the tonic, clear, soft air of the Isles of Shoals in summer has been of immense service. The winds were violent, but the temperature was less severe than in corresponding places on shore. These winds will, however, always prevent many from residing at the Shoals during the winter.

"It may be objected that, in suggesting an island, I virtually ignore all my previous statements in regard to the influence of moisture as a cause of consumption. I answer, first, that it is evident that a small island with an ocean climate may, and probably would, produce very different effects on a patient from those caused by a low and damp place on land. Hence the two places are evidently wholly under different influences. The two spots are not analogous. But second, in the place I have named, I, in reality, do not vary from the rule of dryness of the soil, for they are either mere rocks rising out of the ocean, with no marshes near, or they are masses of sand, so to speak, and are essentially dry of character. Hence they do, in reality, fall within the rule, only they have the oceanic atmosphere instead of the land atmosphere encircling and covering them.

"It is part of my medical faith that within fifty years our community will occupy this and kindred islands as places peculiarly fitted for many of our citizens, who prefer to remain near home to seeking health further south. They will be in some measure to New England what the Isle of Wight is to Great Britain, although the beauties of the two places will be forever very different, and the climate of the Shoals less gracious than that of the mild, almost tropical airs of the Undercliff, or that of

[1] The Sanitarian, vol. xi.

the island of Nantucket, Martha's Vineyard, on our own shores, which experience some of the genial influences of the Gulf Stream."[1]

In Connecticut, the climate is in no material respect different from the interior of the adjacent States. Away from the sea-board the snow lies on the ground for many months, and the winter weather is intensely cold.

In the valley, heavy fogs prevail during a portion of the summer and autumn, and some writers are wont to attribute the large percentage of deaths from consumption to the dampness of the atmosphere from this cause, but there is no excess of consumption in Connecticut over the other New England States; indeed, as may be seen by reference to the table, it is less than in some.

Several contributors to current sanitary literature make it appear that, in recent years, there has been an increase of malarial fevers in New England, particularly in Massachusetts and Connecticut.

But the facts brought out rather indicate that there is an increasing attention to the subject; that from the first, so far as any reliable history of those diseases in New England exists, they have prevailed more or less according to the number of the inhabitants, in various swampy and soil-saturated districts, as they do under favorable temperatures in other regions. The summers and autumns being shorter, their season of prevalence is proportionately so. Moreover, with the same local conditions which promote malarial fevers in warm weather, phthisis and other lung diseases are promoted in cold weather.

The mineral springs of New England most esteemed are, in Massachusetts, *Milford Springs*, near Amherst Station, Hillsborough County, reached via Boston, Lowell, and Concord Railroad. The waters of these springs are mild alkaline, and chalybeate.

ANALYSIS.

Milford Springs.

One pint contains.	Medical Spring. George E. Sewell.	Chalybeate Spr. George E. Sewell.	Ponewah Spring, J. M. Ordway.
SOLIDS.	Grains.	Grains.	Grains.
Carbonate of soda	.....	0.250	0.027
Carbonate of iron	......	0.260	......
Carbonate of lime	......	......	0.042
Chloride of sodium	0.112	0.380	0.024
Sulphate of potassa	0.225	......	0.008
Sulphate of soda	0.070	......	0.047
Sulphate of iron	0.125	......	......
Oxide of iron	......	......	0.011
Phosphate of soda	......	0.537	.....
Phosphate of lime	......	0.325	......
Magnesia	......	......	Trace.
Silica	0.126	0.125	0.156
Total	0.658	1.877	0.317

[1] "Topographical Distribution, etc., of Consumption in Massachusetts," 1862. p. 126–127.

There are two or three other springs at the same place—one magnesia—of the same general character.

Berkshire Soda Spring, near Great Barrington, in Berkshire County, is said to contain chlorine, carbonic acid, alumina, and soda. There is no analysis.

In Vermont there is a considerable variety of mineral waters, and some of them are of high repute.

Highgate Springs, in Franklin County, near Scranton, on the Vermont Central Railroad; *Newbury Springs,* in Orange County, on Connecticut and Passumpsic Railroad to Newburg; and *Alburg Springs,* in Grand Isle County, Alburg Springs Station, on Vermont Central Railroad, have long been known as valuable *sulphur* waters.

Sheldon Springs, in Franklin County, Missisquoi Valley Railroad to Sheldon, are *chalybeate.*

Middletown Springs, in Rutland County, seven miles from Poultney, the nearest railroad station, are *alkaline-calcic.*

ANALYSIS.

Highgate Springs.

One pint contains.	Champlain Spring, A. A. Hayes.	T. Sterry Hunt.
SOLIDS.	Grains.	Grains.
Carbonate of potassa	0.459	......
Carbonate of soda	0.153	0.1713
Carbonate of magnesia	0.152	0.729
Carbonate of lime	0.127	0.175
Carbonate of ammonia	Trace.	......
Chloride of potassium	0.093	......
Chloride of sodium	0.021	2.930
Sulphate of soda	......	0.306
Protoxide of iron	0.004	......
Potassa and boracic acid	......	......
Crenic acid	0.112	......
Silicic acid	0.102	......
Total	1.223	5.853

Newbury Springs.

One pint contains (Prof. Hall):

SOLIDS.	Grains.
Carbonate of soda,	0.50
Carbonate of magnesia,	0.30
Carbonate of lime,	2.20
Chloride of sodium,	0.04
Sulphate of soda,	0.30
Sulphate of magnesia,	.05

	Grains.
Phosphate of iron,	0.05
Protoxide of iron,	trace.
Nitrate of potassa,	0 05
Hydrosulphate of soda,	0.04
Silica and suspended clay,	1.10
Organic matter and ammonia,	0 03
Total,	4.66

Sulphuretted hydrogen gas, undetermined.

Alburg Springs.

One pint contains (C. T. Jackson, M.D.):

Solids.	Grains.
Chloride of sodium,	1.095
Chloride of magnesium,	0.627
Chloride of calcium and carbonate of lime,	1.601
Sulphate of potassium and sulphate of potassa,	1.237
Sulphate of soda,	0.887
Insoluble matters,	0.100
Organic acid of the soil (crenic acid) and loss,	0.250
Total,	4.797

Sheldon Springs.

One pint contains (S. Dana Hayes):

Solids.	Grains.
Potash,	0.012
Sodium,	0.018
Soda,	0.501
Ammonia,	traces.
Lime,	0.134
Magnesia,	0.020
Protoxide of iron,	0.001
Sulphuric acid,	0.063
Silicic acid,	0.573
Carbonic acid (combined),	0.264
Crenic acid and organic matter,	0,358
Chlorine,	0.020
Total,	1.964

This water is chiefly remarkable for the very large proportion of silicic acid it holds in solution—"more," the analyst remarks, "than any other on record."

Middletown Springs.

One pint contains (Prof. Peter Collier):

Solids.	Grains.
Carbonate of soda,	0.402
Carbonate of magnesia,	0.158
Carbonate of lime,	0.418
Carbonate of iron,	0.167
Carbonate of manganese,	0.147
Chloride of potassium,	0.163
Chloride of sodium,	0.027
Sulphate of lime,	0.018
Alumina,	0.010
Total,	1.510

Elgin Spring, in Addison County, a few miles from Vergennes, is *purgative.* Of the water of this spring there is no reliable analysis; but its most active ingredient is said to be sulphate of magnesia. The other ingredients are carbonates of soda and lime, sulphates of soda and iron, and carbonic acid gas.

Welden Spring, near St. Albans, is remarkable for containing iodide of magnesium and crenate of iron. It contains besides carbonates of soda, magnesia, and lime; chloride of sodium, sulphates of potassa and lime.

Clarendon Spring, in Rutland County, West Rutland Station, via Rensselaer and Saratoga Railroad, is of *calcic* water; contains in one pint, carbonate of lime, 0.38 grains; muriate of lime, sulphates of soda and magnesia, 0.34 grains; and free nitrogen (for which it is remarkable) 1.20 cubic inches (A. A. Hayes, M.D.). It also contains a large amount of carbonic acid gas, rendering it acceptable to the stomach.

There are several other springs of local repute, in various parts of the State, but no analyses of the waters exist by which their properties can be determined.

In New Hampshire, the only mineral springs which have attracted public attention are the *Birch-Dale,* near Concord, in Merrimac County. One pint of the water contains (Prof. C. F. Chandler):

Solids.	Grains.
Carbonate of soda,	0.016
Carbonate of magnesia,	0.063
Carbonate of iron,	0.034
Carbonate of lime,	0.182
Chloride of sodium,	0.047
Sulphate of potassa,	0.008
Sulphate of soda,	0.001
Alumina,	0.014

	Grains.
Silica,	0.115
Organic matter,	0.084
Total,	0.596

In Maine, the *Summit* Spring, in Cumberland County, nine miles from Norway Station, on the Grand Trunk Railroad, has recently been advertised a good deal as a "mineral" water of exceptional purity. One pint contains (46° F., F. L. Bartlett):

SOLIDS.	Grains.
Carbonate of soda,	0.175
Carbonate of magnesia,	0.031
Carbonate of lime,	0·123
Chloride of sodium,	0.021
Oxide of iron and alumina,	traces
Silica,	0.122
Organic and volatile matter,	0.029
Total,	0.501

This water contains less of solid constituents than the Croton of New York, or the average of river-water supplies. Its properties are negative.

In Connecticut, *Stafford* Springs, in Tolland County, have long been known, but they have never attracted the attention which the earliest description of them seems to warrant. In Turnbull's History of Connecticut, 1818, is the following account: "The springs are two in number. The first discovered contains iron, held in solution by the carbonic acid, or fixed air, natron or native alkali, a small proportion of marine salt, iodine, soda, magnesia, and some earthy substances. The other is charged principally with hydrogen gas of sulphur; it also contains a very minute portion of iron. The spring first discovered is pronounced by chemists to be one of the best chalybeate springs in the United States." Prof. C. U. Shepard, in his report of the "Geological Survey" of the State, 1837, states that these springs are the most important in the State.

CHAPTER XVI.

THE CLIMATOLOGICAL TOPOGRAPHY AND MINERAL SPRINGS OF THE MISSISSIPPI BASIN.

This is a vast plain of 1,244,000 square miles in extent, which possesses the advantage of being warmed at the north by the great lakes, and on the south by the Gulf of Mexico. The area of the lakes comprehends nearly 100,000 square miles, and this area partakes of the general characteristics—is indeed an extension of the Mississippi Valley into an ascending slope of granite hills and mountains of moderate height on the north, with a descending gradient all the way to the Gulf. Moreover, on each side of this region of the lakes there is a very gradual ascent to the highlands, easterly and westerly, as there is for the whole length of the basin. The attitude of the rise, however, bounding so great an expanse between, exercises but little or no influence on the climate. The warming influence of the lakes in the northern expanse, and the Gulf of Mexico on the southern border, together with the extensive forests throughout, abundantly account for the prevailing high temperature, greater humidity and equability of climate in all respects in this, as compared with corresponding latitudes in the more elevated regions.

Michigan and Wisconsin virtually have the same climate. In the eastern peninsula of the former, there is a rugged range of mountainous hills, whose greatest altitude is about 2,000 feet above the sea level, and 1,400 feet above the level of Lake Michigan. The latter, properly speaking, has no mountains. In the northern portion of the State, an elevation to the extreme height of 1,800 feet, known as the Iron range of hills, divides the tributaries of the Mississippi from the waters which flow into Lake Superior ; and a second range about half as high, which divides the tributaries of the Mississippi from the streams falling into Green Bay and Lake Michigan. There are besides, in both States, several elevations from two or three hundred to about a thousand feet, but none of sufficient altitude to exercise any material influence on the climate, which is greatly modified in both by the proximity of the great lakes. In Michigan, the mean annual temperature of the lower peninsula is about 47° 25′, in the upper, 40° 40′. In Wisconsin, the mean annual temperature is, in the southern border, about 45°; in the northern about 40°.

The peculiarities of the climate of Michigan have recently been admirably summarized by Dr. Henry B. Baker, Secretary of the Michigan State Board of Health, in a contribution to "Descriptive America," under the title of "Climate and Health of Michigan," but it is of much broader significance. The following is an extract:

"The extent of territory north and south is so great that there is a considerable difference between the temperature of the most northern and that of the most southern part of the State. What that difference is, and several other facts, can be well shown by

TABLE 1.

Latitude and Longitude, Elevation above Sea Level, and the Average Temperature, in 1882, *at* 22 *Meteorological Stations in Michigan,—the names of the stations being arranged in order by latitude, highest first.*

Localities in Order of Latitude.—Those Farthest North, First.	Latitude North.	Longitude West from Greenwich.	Altitude (Approximate) above Sea Level.—Feet.	Average Temperature, 1882. Degrees Fahr.
Marquette....................	46°33′	87°36′	638.07	42.28
Escanaba....................	45°46′	87°14′	594.693	42.76
Alpena....................	45°5′	83°28′	587.9	42.68
Traverse City................	44°45′	85°40′	598.	45.13
Harrisville....................	44°39′	83°18′	.....	44.62
Reed City....................	43°44′	85°28′	1,016.	45.63
Otisville	43°13′	83°31′	820.	47.21
Grand Haven................	43°5′	86°18′	595.3	48.18
Port Huron................	42°58′	82°29′	600.	45.78
Thornville....................	42°55′	83°12′	975.	49.02
Lansing	42°44′	84°33′	900.	49.23
Hastings....................	42°40′	85°17′	750.	47.94
Washington	42°40′	83°	746.33	47 85
Winfield....................	42°30′	84°34′	......	47.82
Detroit	42°20′	83°2′	602.6	51.20
Battle Creek................	42°20′	85°11′	800.	50.20
Kalamazoo................	42°18′	85°35′	975.	48.69
Ann Arbor................	42°17′	83°44′	930.	47.31
Marshall................	42°17′	84°58′	885.	49.58
Mendon	42°2′	85°25′	871.	48.51
Tecumseh....................	42°1′	83°57′	835.	48.06
Hillsdale....................	41°55′	84°34′	139.	47.70

"The average temperature for several stations in Michigan for the six years (1877–82), is stated by months, in Table No. 2, which is given below.

"The author of the article on 'Climate,' in the latest edition of the 'Encyclopædia Britannica,' after speaking of a region which he claims presents more sudden transitions of climate than any other portion of the globe, says (page 6, vol. VI.): 'A direct contrast to this is offered

by the United States to the east of the Mississippi, a region characterized by a remarkable uniformity in the distribution of its rain-fall at all seasons, which, taken in connection with its temperature, affords climatic conditions admirably adapted for a vigorous growth of trees, and for the great staple products of agriculture.' He might have added that for similar reasons the climate is also admirably adapted for the maintenance of vigorous health. So far as relates to the equability of the temperature, Michigan is the most favorably situated of these favored States, because of the great lakes which nearly surround the State except on its southern border, and which tend to still further equalize the temperature, by cooling the air in summer and warming it in winter, these being well-known effects of large bodies of water. The modifying effect on the summer temperature is perhaps most noticeable in June, which is a very delightful month in Michigan.

"The average daily range of temperature in Michigan, as shown by self-registering thermometers, is shown in one line of Table 2. If computed from observations made only three times a day, instead of continuously, it would appear much less.

"The absolute humidity of the atmosphere is now known to have close relations to healthfulness, as respects quite a number of diseases; a warm, moist atmosphere being favorable to health so far as regards the lungs and air-passages, and unfavorable to children and others liable to suffer from diarrhœa and diseases of the bowels and digestive organs. The curve in a diagram representing the absolute humidity in Michigan is very nearly the same as the curve representing the sickness reported from diarrhœa. from cholera infantum, or from cholera morbus; and as the quantity of moisture in the air is greatly dependent upon its temperature, increasing as the temperature rises, and decreasing as it falls, any cooling of the atmosphere in summer by the great lakes tends to lessen the actual humidity of the atmosphere at the very time of year when most beneficial, that is to say, when humidity is most harmful; on the other hand, any warming of the winter air, by passing over the great lakes, tends to increase its humidity at the very time of year when most needed, that is to say, when dryness of the air seems to be most harmful;[1] because the investigations which have been carried on in this State during the past ten years have proved that the sickness from bronchitis, and from inflammation of the lungs increases immediately after the occurrence of cold, dry air, and decreases immediately after the occurrence of warm, moist air; the curves for these diseases being somewhat like and following the reversed curve for absolute humidity.

[1] "The writer knows very well that in England it is claimed that it is the cold, *moist* air which is most coincident with diseases of the lungs and air-passages; but it must be understood that when those who have studied the subject in England speak of humidity, they do not mean the *actual* humidity, but, on the contrary, they refer to the *relative* humidity or per cent of saturation, the curve of which is very different from the curve of absolute humidity."

TABLE 2.—*Meteorological conditions in Michigan—the temperature being stated in degrees Fahr.; the absolute humidity in grains of vapor in each cubic foot of air; the relative humidity in hundredths—complete saturation being* 100*; the rainfall in inches; the cloudiness in per cent of sky covered by clouds; the velocity of the wind in miles per hour; and the ozone in degrees of a scale in which the maximum is* 10.

Meteorological Condition.	Annual Aver.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Average temperature[1]	47.61	23.42	27.30	32.49	45.14	57.84	65.42	71.73	69.89	62.41	52.07	35.88	27.72
Daily range of temperature[2]	17.71	16.17	17.33	16.17	19.52	21.34	19.80	19.77	19.15	18 46	17.74	14 55	12.58
Absolute humidity[1]	3.57	1.52	1.67	1.97	2.81	4.07	5.30	6.27	6.10	5.12	3.90	2.32	1.81
Relative humidity[3]	.75	.81	.79	.76	.68	.66	.71	.72	.74	.75	.76	.79	.82
Inches of rain and melted snow[1]	38.67	1.89	2.37	2.97	2.92	3.26	4.29	3.72	3.79	3.59	3.82	3.49	2.65
Per cent of cloudiness[1]	.55	.67	.59	.63	.50	.44	.48	.40	.44	.45	·56	.69	.78
Velocity of wind, per hour and miles[4]	9.6	11.5	11.7	11.8	11.1	10.1	8.7	8.5	6.9	7.5	8.6	8.6	10.1
Ozone (during night)[1]	3.14	3.86	4.00	4.29	3.60	3.18	2.91	2.37	2.20	2.30	2.82	3.41	3.60

[1] Average for six years, 1877–82, at several stations in Michigan. [2] Average for five years, 1878–82, at several stations in Michigan. [3] Average for four years, 1879–82, at several stations in Michigan. [4] Average during the year 1882 by self-registering anemometers at eight stations in Michigan.

"Although the relative humidity has not been proved to have very close relations to health, the facts respecting it may as well be stated, especially as meteorologists have quite generally supposed that it must have great influence. It will be seen from the fourth line in Table 2 that in Michigan the air is not more than three-fourths saturated in any month in summer, when, as we now know, actual humidity of the air is unfavorable, and that the air is more than three-fourths saturated in every month in winter, when, as we now know, a dry, cold air is unfavorable because of its influence in causing diseases of the air-passages. The line referred to is an average line for a period of years, and also an average for several stations; it therefore represents the State as a whole. If we were to examine the averages by months for each year, or for each station, exceptions would be found to the statement just made as to the per cent of saturation of the air in summer and winter, but those statements are made with reference to the State considered as a whole."

Michigan is rich in mineral springs—saline, calcic, sulphur, alkaline, chalybeate, and purgative.

1. SALINE WATERS.

Michigan Congress Spring, Lansing.
One pint contains ($53\frac{1}{2}°$ F., Dr. Jennings):

SOLIDS.	Grains.
Carbonate of soda,	8.094
Carbonate of magnesia,	1.421
Carbonate of iron,	0.143
Carbonate of lime,	7.782
Chloride of sodium,	33.349
Sulphate of potassa,	1.554
Sulphate of soda,	3.131
Silica,	0.413
Total,	55.887

Carbonic acid gas $24\frac{1}{2}$ cubic inches.

Fruit Port Well, Fruit Port, Ottowa County. One pint contains (48° F., C. G. Wheeler):

SOLIDS.	Grains.
Carbonate of soda,	0.565
Carbonate of magnesia,	0.308
Carbonate of iron,	0.680
Carbonate of manganese,	0.010
Carbonate of lime,	0.443
Chloride of potassium,	0.054
Chloride of sodium,	58.003
Chloride of magnesium,	5.851

	Grains.
Chloride of lime,	13.888
Sulphate of soda,	5.749
Bromide of magnesium,	0.095
Silica and silicates,	1.325
Alumina,	trace
Total,	86.971

Spring Lake Well, Spring Lake, Ottowa County. One pint contains (C. G. Wheeler):

SOLIDS.	Grains.
Carbonate of soda,	0.005
Carbonate of magnesia,	trace
Carbonate of iron,	0.092
Carbonate of manganese,	0.006
Carbonate of lime,	0.012
Chloride of potassium,	0.536
Chloride of sodium,	50.691
Chloride of calcium,	4.525
Sulphate of soda,	14.177
Bromide of magnesium,	5.837
Alumina,	0.271
Ammonia,	trace
Lithia,	0.002
Silica,	trace.
Organic matter,	0.063
	2.286
Total,	.78.503

This water, and that of the Fruit Port Well also, are said to resemble the celebrated waters of Kreuznach Springs, in Prussia.

Grand Haven Mineral Springs, Grand Haven, Ottowa County. One pint contains (C. G. Wheeler):

SOLIDS.	Grains.
Carbonate of potassa,	0.343
Carbonate of soda,	0.261
Carbonate of magnesia,	0.190
Carbonate of iron,	0.010
Carbonate of lime,	0.251
Chloride of potassium,	0.241
Chloride of sodium,	38.254
Chloride of magnesium,	8.941
Chloride of calcium,	18.507
Sulphate of soda,	8.911
Iodide of magnesium,	0.006
Bromide of magnesium,	0.022
Fluoride of calcium,	0.006
Alumina,	0.037
Silicic acid,	0.132
Total,	76.112

Mt. Clemens, Macomb County, twenty miles northeast of Detroit, on the Chicago and Grand Trunk Railroad. One pint contains (56° F., H. F. Meier):

SOLIDS.	Grains.
Carbonate of magnesia,	trace
Carbonate of lime,	0.497
Chloride of sodium,	1079.680
Chloride of magnesium,	16.200
Chloride of calcium,	21.552
Sulphate of soda,	9.656
Sulphate of lime,	4.400
Sulphate of iron,	trace
Iodine,	0.040
Silica and alumina,	1.121
Organic matter,	trace
Ammonia,	trace
Potassium salts,	trace
Total,	1133.146

Sulphuretted hydrogen 3.44 cubic inches. Carbonic acid, trace.

2. CALCIC WATERS.

Butterworth Springs, Grand Rapids, Kent County. One pint contains (53° F., S. P. Duffield):

SOLIDS.	Grains.
Carbonate of soda,	0.434
Carbonate of magnesia,	0.432
Carbonate of iron,	0.088
Carbonate of lime,	0.724
Chloride of potassium,	1.227
Chloride of sodium,	1.591
Chloride of magnesium,	5.232
Chloride of calcium,	0.763
Sulphate of lime,	9.392
Silica,	0.064
Alumina,	0.051
Organic matter and loss,	0.083
Total,	20.081

Hubbardston Well, Hubbardston, Ionia County. From Detroit via Detroit and Milwaukee Railroad, to Penamo, thence by stage. One pint contains (Prof. P. H. Douglass):

SOLIDS.	Grains.
Carbonate of magnesia,	0.794
Carbonate of lime,	2.067

	Grains.
Protoxide of iron.	0.019
Silica, ...	0.017
Total, ...	2.879

Eaton Rapids Wells, Eaton Rapids, Eaton County, on Grand River Valley Railroad.

One pint contains.	Frost Well. S. P. Duffield.	Shaw Well. R. C. Kedzie.	Mosher Well. R. C. Kedzie.	Sterling Well. C. T. Jackson.	Bordine Well. R. C. Kedzie.
SOLIDS.	Grains.	Grains.	Grains.	Grains.	Grains.
Carbonate of potassa......	....	0.159	0.144	....	0.284
Carbonate of soda.........	....	0.446	0.672	0.542	0.472
Carbonate of magnesia....	0.949	0.480	0.565	...	0.622
Carbonate of iron...... ..	0.248	0.154	0.125	0.292	0.203
Carbonate of lime.	4.816	2.592	2.429	....	3.513
Chloride of sodium........	0.959	0.112	0.112	....	0.187
Sulphate of soda	....	....	....	1.311	....
Sulphate of magnesia......	....	...	....	0.978	....
Sulphate of lime	0.483	6.016	5.645	5.748	7.187
Nitrate of ammonia.......	....	trace	trace	....	....
Silicic acid............ ...	....	0.175	0.317	....	....
Silica....................	1.639	....	....	....	0.250
Organic matter and loss...	0.094	0.112	0.106	....	....
Total...............	9.188	11.246	10.115	8.871	12.718
GASES.	Cubic in.	Cubic in.	Cubic in.	Cubic in.	Cubic in.
Carbonic acid............	2.32	2	1.92	2	2
Sulphuretted hydrogen....	....	trace	trace	....	....

3. SULPHUR WATERS.

Alpena Well, Alpena, Alpena County. Steamboat from Bay City. One pint contains (52° F., S. P. Duffield):

SOLIDS.	Grains.
Carbonate of potassa, ...	trace
Carbonate of soda, ...	1.364
Carbonate of magnesia, ...	4.661
Carbonate of iron, ...	0.170
Carbonate of lime, ...	4.787
Chloride of sodium, ...	8.532
Sulphate of lime, ...	3.757
Alumina and silica, ...	0.386
Total, ...	24.657

Gases.	Cubic in.
Carbonic acid,	1.05
Sulphuretted hydrogen,	4.42
Nitrogen,	0.03

4. ALKALINE WATERS.

St. Louis Spring, St. Louis, Gratiot County, on railroad from East Saginaw. One pint contains (50° F., S. P. Duffield, M.D.):

Solids.	Grains.
Carbonate of soda,	7.684
Carbonate of magnesia,	1.080
Carbonate of iron,	0.091
Carbonate of lime,	5.019
Chloride of lime,	trace
Sulphate of lime,	6.955
Silicate of lime,	0.700
Silica,	0.299
Organic matter and loss,	0.208
Total,	22,006

Gases: Carbonic acid, 1.36 cubic inches; sulphuretted hydrogen, trace.

5. CHALYBEATE WATERS.

Owosso Spring, Owosso, Shiawassee County, on Detroit and Milwaukee Railroad. One pint contains:

Solids.	Grains.
Carbonate of magnesia,	1.413
Carbonate of iron,	1.443
Carbonate of lime,	2.228
Chlorides of sodium and potassium,	0.262
Silica and alumina,	0.077
Total,	5.423

6. PURGATIVE WATERS.

Midland Well, Midland, Midland County, on Flint and Père Marquette Railroad. One pint contains (47° F., S. P. Duffield, M.D.):

Solids.	Grains.
Chloride of sodium,	3.405
Chloride of magnesium,	0.228
Chloride of calcium,	0.647
Sulphate of potassa,	8.559
Sulphate of soda,	2.298
Sulphate of lime,	0.464
Phosphate of alumina,	0.180
Silica,	0.308

	Grains.
Organic matter	0.257
Loss,	0.339
Total,	16.680

There are several other springs of local repute in Michigan, with properties more or less approximating those above given.

In Wisconsin, the *Bethesda Springs*, at Waukesha, Waukesha County, on the Prairie du Chien Railroad, are of considerable reputation for their *calcic* properties. One pint contains (60° F., Prof. C. F. Chandler):

Solids.	Grains.
Carbonate of soda,	0.109
Carbonate of magnesia,	0.918
Carbonate of iron,	0.004
Carbonate of lime,	1.478
Chloride of sodium,	0.145
Sulphate of potassa,	0.057
Sulphate of soda,	0,068
Phosphate of soda,	trace
Alumina,	0.015
Silica,	0.092
Organic matter,	0.248
Total,	3.134

Silurian Springs, also at Waukesha, possesses properties similar to the Bethesda.

Sparta Springs, Sparta, Monroe County, on Chicago, Milwaukee, and St. Paul Railroad, two hundred and fifty miles from Chicago, possess strong *chalybeate* properties, in conjunction with aperient sulphates. One pint contains (J. M. Hersh):

Solids.	Grains.
Carbonate of soda,	0.026
Carbonate of magnesia,	0.503
Carbonate of iron,	1.792
Carbonate of manganese,	trace
Carbonate of lime,	0.050
Carbonate of ammonia,	trace
Carbonate of lithia,	0.003
Carbonate of strontia,	0.002
Carbonate of baryta,	trace
Sulphate of potassa,	0.080
Sulphate of soda,	0.277
Sulphate of lime,	0.022
Chloride of sodium,	0.018
Chloride of calcium,	0.075
Phosphate of soda,	0.008
Phosphate of alumina,	0.007

	Grains.
Iodide of sodium, ...	trace
Silica, ...	0.035
Total, ...	2.898

Sulphuretted hydrogen gas, a trace.

Minnesota has an average elevation of about 1,275 feet above the level of the sea, varying from 600 to about 2,500. It has extensive pine forests, and a climate of high repute for consumptives.

Observations extending over a period of thirty-five years record an annual mean temperature in spring and autumn, 45°; summer, 70°; and in winter, 16°.

Dr. C. N. Hewitt, Secretary of the State Board of Health, recently submitted meteorological statistics of the State to the World's Industrial Exposition in New Orleans, as follows:

"Mean temperature of all Minnesota below 47th meridian of latitude, except east half of counties along Iowa line, 40°.

"This (40°) is also the summer mean of the Red River Valley as far north as Pembina.

"Rest of State, extending to Rainy River, has mean temperature 36° F."

This following table gives mean annual temperature for nine years.

[1] Averages of Years 1875 to 1884 inclusive.	Temperature.	Humidity.
1. 1876—November, 1875, to November, 1876......	42.50	68.06
2. 1877— " 1876 " 1877......	43.73	66.67
3. 1878— " 1877 " 1878......	48.25	69.81
4. 1879— " 1878 " 1879......	43.54	67.66
5. 1880— " 1879 " 1880......	45.90	67.95
6. 1881— " 1880 " 1881......	42.02	68.51
7. 1882— " 1881 " 1882......	45.14	68.38
8. 1883— " 1882 " 1883......	39.96	71.54
1884—January, 1884, to January 1885 (for St. Paul),	43.78	72.70
Average for nine years...........................	43.95	69.03
Average for fourteen years at St. Paul	45.2	69.1

Rain-fall of different parts of State is as follows:

[1] Stations of observation, in number eight to twelve at different times, included the extremes of the State, Duluth in N.E., Winona in S.E., Moorhead in N.W., and St. Peter in S.W., and several intermediate stations. Taken from the State Board of Health Meteorological Reports.

Big Stone region,	Average annual,	28	inches.
Southeast portion,	"	40	"
Head of Mississippi,	"	24	"
Near Pembina,	"	20	"

For nine years ending 1883, melted snow and rain-fall by seasons is:

Winter months ranged,	1.64 to	4.69	inches.
Spring " "	6 "	9.76	"
Summer " "	9.12 "	13.89	"
Autumn " "	4.56 "	7.80	"
For St. Paul, during 1884, total rainfall (including snow) was,		26.11	"
Average for fourteen years,		28.98	"

Dakota, Nebraska, and Iowa have the same suface characteristics in general as, but less elevated than, Minnesota. Diversified by high rolling lands and corresponding valleys, Iowa is exceptional in being more level, and with an average elevation above the level of the sea of only about 850 feet. There is comparatively little swampy land, however, in any of these States. The climate is considerably modified by extensive forests, and is generally healthy.

Illinois seems to begin, as it were, in an altitude of about 800 feet above the sea-level at its northern and northeastern boundary, and gradually descends toward the Mississippi and Ohio Rivers. There are a few bluffs and hills in the N. W. section of the State, but none of greater height than 800 feet. The Grand Prairie at its highest part is only 500 feet above the level of the sea; and at its lowest portion, at the junction of the Mississippi and Ohio, it is only 340 feet above the level of the Gulf of Mexico. The State is, therefore, very nearly level. Yet, stretching as it does over five and a half degrees of latitude, there is, of course, considerable variety in the climate. In the northern portion the temperature is about the same as the southern portion of the adjacent States. For special data of meteorological records, the tables on other pages may be referred to.

The climate is generally healthy. But in certain low and swampy bottom lands in the southern part of the State, intermittent and remittent fevers, and other malarial diseases, are commonly prevalent in the summer and autumn. As may be seen by table, the ratio of deaths from consumption is relatively small.

Indiana and Ohio virtually occupy the same plane. Both are devoid of mountains. The table land of Ohio, the watershed which divides the streams which flow into Lake Erie from those which flow into the tributaries of the Ohio River, is elevated above the level of the sea from 1,000 to 1,400 feet. Besides this, there are no elevations in either of these States above 700 feet. But the climate is far from being equable, probably due, particularly in Ohio, to the destruction of the forests. Sixty

years ago, more than four-fifths of the surface of this State was covered with forests; now there is less than one-fifth, and the destruction still goes on. In Indiana, the devastations in this respect have been less; but they are in rapid progress, with a continuous increase of exposed surface to the parching rays of the summer sun, and to the blasts of the winter winds. The extremes of temperature, as may be seen by reference to the table, are great in both.

The climate of Kentucky is, in general, delightful. The State is divided into two unequal areas: the mountain district in the eastern and southeastern portion, and the southwestern table land, extending to the banks of the Mississippi. In the former, the Cumberland and Pine Rivers, which maintain the general characteristics of the Alleghanies, reach an altitude above the level of the sea of about 3,000 feet, tapering off into a succession of lower ridges, until they spend themselves in hills of from 400 to 1,000 feet over the latter. Lexington, which is situated on the highest point of the table lands, is 1,070 feet above the sea-level.

The mean annual temperature of the State is about 55°, and the extremes, not often reached, from 0 to 100°.

In Dakota, Nebraska, and Iowa, no mineral springs of importance have as yet been described.

In Illinois, the *Perry Springs,* in Pike County, six and a half miles from Griggsville, a station on the Hannibal and Naples Railroad; and *Versailles Springs,* Versailles, Brown County, a station on the Toledo, Wabash, and Western Railroad, possess valuable *alkaline* properties.

Perry Springs.

One pint contains.	Middle Spring. H. Englemann, M.D.	Upper Spring. H. Engelmann, M.D.	Lower Spring. H. Engelmann, M.D.
SOLIDS.	Grains.	Grains.	Grains.
Carbonate of potash	0.199	0.181	0.157
Carbonate of magnesia	1.260	1.097	0.777
Carbonate of iron	0.051	0.040	0.025
Carbonate of lime	1.380	1.715	1.708
Sulphate of soda	0.055	0.137	0.173
Silicate of potassa and soda	0.330	0.285	0.431
Silicate of sodium	0.015	0.048	0.072
Silicate of alumina	.....	.....	0.034
Total	3.290	3.503	3.377

Schuyler County Springs (Chalybeate).

One pint contains (Dr. Blaney):

SOLIDS.	Grains.
Sulphate of magnesia,	0.373
Sulphate of lime,	9.242
Protosulphate of iron,	8.745
Silica,	0.164
Alkaline sulphates,	0.979
Total,	19.503

Versailles Springs.

One pint contains.	Magnes G. A. Marriner.	Curry Spring. J. V. Z. Blaney, M.D.	Monitor Spring. J. V. Z. Blaney, M.D.
SOLIDS.	Grains.	Grains.	Grains.
Carbonate of potassa and soda	0.165	trace	trace
Carbonate of soda	.....	0.953	0.953
Carbonate of magnesia	1.119	0.933	0.873
Carbonate of iron	0.008	.....	0.267
Carbonate of lime	1.825	1.514	2.017
Chloride of sodium	trace	trace	trace
Sulphate of lime	trace	0.261	.....
Potassa	.....	.....	.....
Alumina and trace of iron	.....	0.091	.....
Silica	0.175	0.102	0.213
Organic matter	....	trace	trace
Total	3.292	3.854	4.323
Carbonic acid, 3 cubic inches.			

In Indiana, there are several *sulphur* springs of considerable value, and one *chalybeate.*

West Baden Spring, one mile distant from French Lick, is *saline sulphur.* One pint contains (E. T. Cox):

SOLIDS.	Grains.
Carbonate of potassa,	0.078
Carbonate of soda,	0.139
Carbonate of magnesia,	4.895
Carbonate of lime,	5.172
Chloride of sodium,	9.748
Chloride of magnesium,	1.425
Chloride of calcium,	0.910
Sulphate of potassa,	0.175
Sulphate of soda,	0.388
Sulphate of magnesia,	4.519
Sulphate of lime,	1.398
Sulphate of alumina,	0.569
Oxide of iron,	0.011
Iodides and bromides,	traces
Silicic acid,	0.055
Total,	29.478

Gases.	Cubic in.
Carbonic acid,	0.64
Sulphuretted hydrogen,	0.61
Oxygen,	0.21
Nitrogen,	0.68
Total,	2.14

French Lick Springs, Orange County, Ind., fifteen miles by stage from Shoals, a station on the Ohio and Mississippi Railroad.

One pint contains.	Pluto's Well. J. G. Rogers, MD.	Proserpine. J. G. Rogers, M.D.
Solids.	Grains.	Grains.
Carbonate of soda	......	1.316
Carbonate of magnesia	0.198	0.562
Carbonate of iron and alumina	trace	0.312
Carbonate of lime	0.868	2.536
Chloride of potassium	......	0.626
Chloride of sodium	17.567	11.365
Chloride of magnesium	......	1.006
Chloride of calcium	0.668	......
Sulphate of soda	2.796	4.590
Sulphate of magnesia	2.264	3.666
Sulphate of lime	7.573	17.625
Silica	.....	0.212
Total	31.934	43.816
Gases.	Cubic inches.	Cubic inches.
Carbonic acid	1.87	1.277
Sulphuretted hydrogen	3.18	2.125
Total	5.05	3.402

Indian Springs (saline-sulphur), Martin County, nine miles from Shoals station, Ohio and Mississippi Railroad. One pint contains (53° F., E. T. Cox):

Solids.	Grains.
Carbonate of potassa,	0.315
Carbonate of soda,	0.452
Carbonate of magnesia,	2.368
Carbonate of lime,	4.138
Chloride of soda,	4.921
Chloride of magnesium,	0.007
Sulphate of potassa,	0.300
Sulphate of soda,	1.478
Sulphate of magnesia,	3.799
Sulphate of lime,	2.529
Sulphate of alumina,	0.104
Oxide of iron,	trace

	Grains.
Iodides and bromides,	trace
Silicic acid,	0.056
Total,	20.467
GASES.	Cubic in.
Carbonic acid,	1.19
Sulphuretted hydrogen,	0.42
Oxygen,	0.49
Nitrogen,	0.81
Total,	2.91

Lodi Artesian Well, Lodi, Wabash County, on Indianapolis and St. Louis Railroad, fifty-eight miles west of Indianapolis, is also said to be a very valuable *saline-sulphur* water.

One pint contains (Dr. Pahle):

SOLIDS.	Grains.
Carbonate of magnesia,	0.082
Carbonate of lime,	0.252
Chloride of sodium,	62.808
Chloride of magnesium,	6.692
Chloride of calcium,	5.991
Sulphate of potassa,	0.100
Sulphate of soda,	0.267
Sulphate of magnesia,	0.407
Sulphate of lime,	6.944
Phosphate of lime,	0.150
Iodide of magnesium,	0.110
Silicic acid,	0.065
Nitrogenous organic matter,	0.100
Sulphur (mechanically suspended),	0.625
Total,	84.593
GASES.	Cubic in.
Carbonic acid,	undetermined.
Sulphuretted hydrogen,	0.99
Oxygen and nitrogen,	undetermined.

Lafayette Well, Lafayette, Tippecanoe County; and *Trinity Springs,* Martin County, also produce excellent *saline-sulphur* waters.

Greencastle Springs, Greencastle, Putnam County, thirty-eight miles west from Indianapolis via railroad, are *chalybeate.*

One pint contains.	North or Daggy Spring, 56° F.	Middle or Dew-Drop Spr. 52° F.
SOLIDS.	Grains.	Grains.
Carbonate of potassa	0.011	0.009
Carbonate of soda	0.012	0.008
Carbonate of magnesia	0.588	0.667
Carbonate of protoxide of iron	0.051	0.298
Carbonate of lime	1.819	1.485
Chloride of sodium	0.099	0.087
Sulphate of soda	0.017	0.012
Sulphate of magnesia	0.131	0.129
Alumina	0.020	0.009
Silicic acid	0.011	0.001
Loss and undetermined	0.012	0.028
Total	2.771	2.783

The mineral waters of Kentucky are chiefly *saline-sulphur* and *purgative*. Of the former kind, the *Blue Lick Springs*, in Nicholas County, have long been famous for their efficacy in liver engorgements. The *Upper* Blue Lick Spring contains, in one pint (62° F., I. F. Judre and A. Fennel):

SOLIDS.	Grains.
Carbonate of magnesia	0.018
Carbonate of lime	3.133
Chloride of potassium	0.225
Chloride of sodium	64.567
Chloride of magnesium	4.716
Sulphate of potassa	1.622
Sulphate of lime	5.517
Iodide of magnesium	0.019
Bromide of magnesium	0.476
Alumina: phosphate of lime and peroxide of iron	0.246
Silicic acid	0.125
Loss	1.860
Total	82.524
GASES.	Cub. in.
Carbonic acid	6.02
Sulphuretted hydrogen	1.02

The *Lower* Blue Lick Spring contains the same constituents as the "Upper," but more carbonic acid, and possesses similar properties.

The *Louisville Artesian Well*, located at the paper mill of A. V. Dupont & Co., Louisville, is also a pronounced *saline-sulphur* water of excellent quality. One pint contains (76½° F., Prof. J. Lawrence Smith):

SOLIDS.	Grains.
Carbonate of soda	0.237
Carbonate of magnesia	0.204
Carbonate of iron	0.032
Carbonate of lime	0.520

	Grains.
Chloride of potassium,	0.528
Chloride of sodium,	77.690
Chloride of magnesium,	1.847
Chloride of aluminum,	0.151
Chloride of calcium,	8.216
Chloride of lithium,	0.013
Sulphate of potassa,	0.403
Sulphate of soda,	9.037
Sulphate of magnesia,	9.667
Sulphate of alumina,	0.225
Sulphate of lime,	3.679
Phosphate of soda,	0,193
Iodide of magnesium,	0.044
Bromide of magnesium,	0.058
Silica,	0.111
Organic matter,	0.089
Loss,	1.015
Total,	113.959
GASES.	Cubic in.
Carbonate acid,	0.77
Sulphuretted hydrogen,	0.25
Nitrogen,	0.17

Olympian Springs, Bath County, reached by stage from Mount Stirling, on Lexington and Big Sandy Railroad, are designated by Dr. Peter *salt-sulphur.* One pint contains:

SOLIDS.	Grains.
Carbonate of magnesia,	0.904
Carbonate of iron,	trace
Carbonate of lime,	1.742
Chloride of potassium,	1.334
Chloride of sodium,	20.752
Chloride of magnesium,	6.924
Sulphate of lime,	trace
Bromine and iron,	trace
Alumina,	trace
Silica,	0.131
Water and loss,	9.825
Total,	41.612

Drennon Springs, Henry County, about ten miles from Newcastle; *Bedford Springs,* Trimble County; *White Sulphur and Tar Springs,* Breckenridge County; *Milldale Mineral Well,* Kenton County; *Grayson Springs,* in Grayson County; and *Esculapian Springs,* Lewis County, are all saline-sulphur springs of good local repute as active diuretics, diaphoretics, and slightly aperient.

Estill Springs, in Estill County, comprehend both *chalybeate* and *purgative* waters. Of the *chalybeate* spring one pint contains (Dr. Peter):

SOLIDS.	Grains.
Carbonate of magnesia,	0.335
Carbonate of iron,	0.233
Carbonate of lime,	1.159
Chloride of sodium,	0.066
Sulphate of potassa,	0.080
Sulphate of soda,	0.087
Sulphate of magnesia,	1.224
Sulphate of lime,	2.084
Alumina and trace of phosphates,	trace
Silica,	0.233
Organic and volatile matter,	1.028
Total,	6.529

Carbonic acid gas, 4.15 cubic inches.

Of the *purgative* spring, one pint contains (Dr. Peter):

SOLIDS.	Grains.
Carbonate of magnesia,	0.321
Carbonate of iron,	0.166
Carbonate of lime,	3.841
Chloride of sodium,	2.201
Chloride of calcium,	0.211
Sulphate of potassa,	0.313
Sulphate of magnesia,	32.910
Sulphate of lime,	3.987
Silica,	0.503
Loss,	10.736
Total,	55.189

But the most celebrated purgative waters of the State are the *Crab-Orchard Springs,* Lincoln County, on Louisville and Nashville Railroad.

One pint contains.	Foley's Spring. R. Peters, M.D.	Sowder's Springs. R. Peters, M.D.
SOLIDS.	Grains.	Grains.
Carbonate of magnesia	0.955	2.734
Carbonate of iron	trace	trace
Carbonate of lime	6.648	3.689
Chloride of sodium	2.216	7.290
Sulphate of potassa	1.239	2.172
Sulphate of soda	7.384	2.900
Sulphate of magnesia	25.660	21.789
Sulphate of lime	1.349	11.146
Bromine	. ..	Trace.
Silica	0.408	0.153
Loss and moisture	4.323	......
Total	50.182	52.143

These waters are chiefly used for the production of *Crab-Orchard Salts,* by boiling down the water, of which thousands of pounds are sold

annually, and used as a substitute for Epsom salts, than which they are less irritant, and, in biliary engorgements, taken in small and repeated doses, more efficacious.

Harrodsburg Springs, Mercer County, station on Southwestern Railroad, have similar properties to the Crab-Orchard Springs, but milder.

The climate of Tennessee is a continuation of that in Kentucky, with an increasing temperature corresponding with latitude, but with the advantage of a greater variety, by reason of a considerably more extensive mountainous area. The Alleghany Mountains extend throughout the eastern portion of the State, to the extent of about 2,000 square miles and attain an altitude of 5,000 feet above the level of the sea. West of this continuous elevated region, and between it and a ridge of the same system of mountains, called the Unaka Mountains, and the Cumberland table-land, is the valley of east Tennessee. This extends from N. E. to S. W. in a succession of ridges and valleys, comprehending an area of 9,200 square miles, with an average altitude of about 1,000 feet above the sea, bordered on both sides by much higher lands. Next follows the Cumberland table-land, a rocky plateau of 5,000 square miles, 2,000 feet above the level of the sea; this grades off into a terraced descent, called rim-lands, which extend to the Tennessee River, with an average elevation of about 1,000 feet above the sea, and comprehends an area of 9,300 square miles. In the middle of this region lies the Central Basin—a depression of 5,455 square miles 300 feet below the rimlands; and finally, beyond the western edge of the high lands, is the narrow western valley of the lower Tennessee and its smaller affluents, penetrated by outlying spurs, and corresponding valleys of its eastern boundary. From this there is a gradual slope toward the Mississippi River, which terminates a short distance from its bank into an abrupt bluff with an average elevation of about 300 feet above the level of the Gulf of Mexico. It is apparent that with such a surface, the climate of Tennessee exists in great variety, and as a whole it is probably unexcelled in salubrity.

The mean temperature of the year along the line moving E. and W. through the State is in east Tennessee, 57°; Middle Tennessee, 58°; West Tennessee, 59°. Along the southern boundary of the State it is respectively in corresponding localities, 58°, 59°, and 60°. Along the northern border, 56°, 57°, and 58°. In this statement the valley of East Tennessee is not included; this at the northern border has a mean of about 55°, and at the southern, about 58°.

The following summary from authentic data, in addition to general tables on previous pages, gives the average mean temperatures, rain-fall, date of frosts, and the prevailing winds at the several different localities named:

METEOROLOGICAL DATA.	Knoxville, lat. 35° 56', lon. 58'; elevation 993 feet.	Lebanon, lat. 36° 17', lon. 86° 23'; elevation about 536 feet.	Nashville, lat. 36° 11', lon. 86° 53'; elevation 504 feet.	Glenwood (Montgomery Co.), lat. 36° 29' 12", lon. 87° 07' 30"; elevation 500 feet.	Falls of Caney Fork, lat. 35° 47', lon. 84° 44'; elevation 1,092 feet.	Memphis, lat. 35° 07', lon. 70° 07'; elevation 292 feet.
	°	°	°	°	°	°
Average mean annual temperature.	57.03	57.76	58.47	57.26	58.48	61.60
Aver. maximum temp. of the year.	92.	97.	95.	92.90	94.50	101.50
" minimum " " ..	6.	6.	5.	3.25	3.	....
Range of annual temperature......	86.	91.	90.	89.65	91.50	....
Average mean temp. of spring ...	56.3	58.64	58.93	56.71	58.86	60.13
Maximum temp. of spring........	90.	91.	91.	84.	90.	87.
Minimum " "	6.	12.	11.	31.	10 50	30.
Range of temp. in spring..........	84.	79.	80.	53.	79.50	57.
Average mean temp. of summer..	74.02	75.41	74.33	74.40	74.27	75.57
Maximum temp. of summer.......	92.	97.	95.	92.90	94.50	101.50
Minimum " "	61.	77.	66.	48.	65.	58.50
Range of temp. in summer........	31.	51.	29.	44.90	29-50	43.
Average mean temp. of autumn...	55.40	57.61	58.80	57.54	58.56	59.40
Maximum temp. of autumn......	91.	94.	95.	86.	90.	90.
Minimum " "	15.	19.	20.	15.	21.	28.
Range of temp. in autumn........	76.	75.	75.	71.	69.	62.
Average mean temp. of winter ...	38.66	38.	41.20	37.87	40.97	44.66
Maximum temp. of winter........	69.	72.50	73.	74.	68.	....
Minimum " "	6.	6.50	5.	3.25	3.	....
Range of temp. in winter..........	63.	66.	68.	70.75	65.	....
	Inches.	In.	Inches.	Inches.	In.	Inches.
Average annual rain-fall..........	59.25	43.61	54.74	53.48	58.47	49.30
Rain-fall in spring................	12.60	10.55	15.03	13.41	12.35	17.40
" " summer......	13.15	9.57	14.37	13.32	14.02	7.29
" " autumn...............	12.40	7.54	13.39	11.63	11.83	14.54
" " winter................	21.10	15.95	11.95	15.12	20.27	6.93
Date of last frost in spring (average of from 3 to 23 years)...........	Apr. 10	.....	....	Apr. 17	.....	....
First killing frost in autumn......	Oct. 18	....	....	Oct. 20	.....	....
Number of days without frost.....	166	....	...	173	.....	....
Number of days without killing frost...	181	....	....	180	.....	....
Prevailing winds in order of frequency	S.W.,N.E. N., S., W., E., calm N.W.,S.E.	....	Calm NW S.W., N. S.E., E... S.W.,N.E.	S., N.W., N.E.,calm S.E., N., SW., E.W.	....	NW.,S.W. N.E.,S.E., calm S., N.

The only mineral springs of note in Tennessee are the *Montvale Springs* (*calcic chalybeate*), delightfully situated in the Chilhowee Mountains, in Blount County, nine miles from Maryville, a station on Knoxville and Charleston Railroad.

One pint contains.	60° F. Prof. F. B. Mitchell.	60° F. J. R. Chilton, M.D.
SOLIDS.	Grains.	Grains.
Carbonate of iron	0.300	.....
Carbonate of lime	1.657	.....
Chloride of sodium	0.245	....
Chloride of magnesium	.....	0.012
Chloride of calcium	.....	0.018
Sulphate of soda	0.564	1.102
Sulphate of magnesia	1.500	2.134
Sulphate of lime	9.276	10.243
Oxide of iron	.....	0.149
Alumina	0.062	.....
Silica	.....	trace
Organic matter	.....	0.005
Total	13.604	13.663

Florida is an extensive peninsula 450 miles long from north to south, and with an average breadth, between the Gulf of Mexico on the west and the Gulf Stream on the east, of a little less than 90 miles.

Of the face of the country it may be truly said the most characteristic feature is the everglades and the number of lakes. But there is also a great number of running streams, sluggish though many of them are, and not a few with extensive swampy borders. There are also many springs, and some of them of immense size, and strongly impregnated with sulphur and lime.

The surface of the State is generally level, the greatest elevations being not more than from three hundred to five hundred feet above the level of the Gulf, and these heights being attained in very few places. The soil is alluvial and diluvial. In the interior and most elevated portion, it is composed of clay intermingled with a calcareous formation, resting upon coral beds evidently of great age.

The lands are generally classified as high-hammock, low-hammock, savanna, swamp, and pine. The pine lands are the most extensive, and some of its forests rival those of the Atlantic slope. The hammocks also are very extensive, and covered with live oak and other oaks, hickory, gum, magnolia, and luxuriant undergrowth.

The climate is essentially insular and oceanic, in conjunction with the forest, under peculiar circumstances.

Those who would measure climate at the level of the sea by the meridian only will wholly fail to form a correct conclusion in regard to the climate of Florida.

Northern Mexico, the peninsula of California, the Desert of Sahara, Central Arabia, Northern Hindostan, Northern Burmah, Southern China, and numerous other regions of less note, and some of them insular, in the same latitude as Florida, have climates more or less similar to one another, but all strikingly dissimilar from that of Florida; and

for the manifest reason that none of them are bounded by an immense body of warm water on one side, and a swiftly flowing ocean current on the other, and the peninsula between covered by a luxuriant forest—a combination of conditions for the production, maintenance, and modification of an ocean and forest atmosphere that exists nowhere else to the same degree, and which results in a climate peculiarly its own, remarkable for its salutary influences as a winter resort for invalids with pulmonary consumption.

The climate of Florida is well described by the following extract from a pamphlet of the "State Bureau of Immigration:"

"The climate of Florida is not a hot climate in summer, but mild and not subject to great changes in temperature. The winters are not cold and freezing, but uniformly cool and bracing. Throughout the whole twelve months, the rainy, cloudy, disagreeable days are an exception; fair, bright, sunny days are the rule. The thermometer seldom goes below 30° in winter and rarely above 90° in summer. The official records show the average of summer, 78°; of winter, 60°. The daily constant ocean breezes in summer modify the heat (the Gulf-breeze coming, with the setting sun, cools the air at night); a warm or sultry night is almost unknown. Official sanitary reports, both of scientific bodies and the army, show that Florida stands first in health, although in the reports are included the transient or recent population, many of whom take refuge here as invalids, some in the lowest stages of disease. In the greater portion of the State, frost is rarely known. The summer is longer, but the heat less oppressive than midsummer at the North; this results from its peculiar peninsular shape and the ever-recurring breezes which pass over the State. For days together, New York, Boston, and Chicago show in summer temperature as high as 100°; it is very rare that it reaches that degree in Florida for a single day, generally ranging below 90°; not oppressive, modified by the ever-changing air; not sultry, close, or humid [1]; mornings and evenings always cool and bracing. . . .

"There are years when in some localities there is a drought, and years when portions of the State have had excessive rains, but they do not extend far."

Jacksonville, latitude 30° 15′ north; longitude 82° west, according to recorded observation thrice daily for twenty years, by Dr. E. S. Baldwin, give a mean temperature for—

January,	55°	July,	82°
February,	58°	August,	82°
March,	64°	September,	78°
April,	70°	October,	70°
May,	76°	November,	62°
June,	80°	December,	52°

[1] See table of Humidities. Author.

PLACES.	Latitude.	Mean Temperature, January.	Mean Temperature, February.	Mean Temperature, March.	Mean Temperature, April.	Mean Temperature, May.	Mean Temperature, June.	Mean Temperature, July.	Mean Temperature, August.	Mean Temperature, September.	Mean Temperature, October.	Mean Temperature, November.	Mean Temperature, December.	Mean Temperature, yearly average.	Yearly Rainfall, 1871-1872.
St. Augustine	29° 53′	57.03	59.94	63.34	68.78	73.50	79.36	80.90	80.56	78.60	71.88	64.12	57.26	69.61	47.86
Tampa Bay	27° 56′	61.53	63.54	67.72	71.82	76.69	70.46	80.72	80.43	78.28	74.02	66.94	61.99	71.92	33.17
Key West	24° 36′	66.68	68.88	72.88	75.38	79.10	81.63	83.00	82.90	81.92	78.11	74.66	71.03	76.51	36.49
Jacksonville	30° 15′	59.38	55.50	61.20	67.20	75.70	79.20	84.10	84.47	77.20	73.00	62.70	53.30	69.60	53.95
Fort Dallas	25° 45′	66.40	66.60	70.40	75.60	77.00	80.50	82.10	81.80	79.60	77.90	71.30	66.80	74.80	32.97
Fort Meyers, or Punta Rasia	27°	63.40	68.00	72.20	73.80	80.10	81.20	82.90	83.10	81.70	77.70	71.50	64.70	75.00	40.87
Lake City, 1871	30° 06′	49.00	53.50	57.60	71.60	78.10	79.30	81.20	79.40	76.50	71.00	63.00	53.00	67.80	47.12

The Spanish records of St. Augustine show that for 100 years the mean temperature of the winter months averaged a little over 60°, and of the summer months 86°. The extremes of the year, taking the peninsula together, show about 35° as the coldest and 95° as the hottest temperature, and neither extreme is reached more than two or three times in the year. The summer lasts seven or eight months, and during the whole period there are very few uncomfortably hot days, the sea-breezes tempering the air, and the nights are uniformly cool. The rainy season usually extends over three or four months, but it only consists of more frequent showers than through the other months, and sometimes heavy and drenching rains, but seldom of more than four hours' duration. Occasionally there are long droughts in some sections, and heavy rains in others. The preceding table, made up from the army and Signal Service records and other reliable data, gives the data for the points named in addition to other data in the previous chapter.

The climate of Southern Georgia, Alabama, Mississippi, Louisiana, and Southern Texas, is for about two-thirds of the year hot; and along the coast and river valleys unhealthy. Endemic malarial fevers here prevail more or less, annually, and sometimes with great severity. And at such sea ports of the Southern Atlantic and Gulf coast as have been or are now kept in a state of receptivity—by the accumulation of filth—yellow fever is, as it has always been, wont to make ports of entry.

The climate of Southern Texas, as described by Assistant Surgeon P. F. Harvey, U. S. Army,[1] is, "in the aggreate subtropical, but torrid heats prevail during the summer months.

"During the hotter periods of the year, the mercury indicates a temperature over 100° in the shade for weeks at a time occasionally. At such times, hot dry winds, comparable to the simoons of Arabia, blow from the parched plateaus of Mexico, wilting the vegetation and compelling the closure of doors and windows to exclude the dust and heat. The prevailing winds for all seasons are from the southeast. Sudden storms of wind from the north, with or without rain, attended with rapid lowering of the temperature, called wet or dry northers, are frequent in winter. The atmosphere is generally dry; beef used by the Mexicans is prepared and preserved by drying it in the open air, desiccation taking place rapidly and thoroughly. . . .

"Diarrhœa and dysentery may be regarded as the prevailing diseases. . . . Rheumatism and neuralgia prevail to a considerable extent.

"Diseases of the lungs and air-passages were of infrequent occurrence and mild grade. Catarrhal affections were most prevalent during the winter months and were due to climatic influences. Malarial fevers

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[1] Ringold Barracks, on the Rio Grande; latitude, 26° 23′ north; longitude, 21° 50′ west; altitude, 521 feet. Op. cit., p. 229.

were rare among the troops (colored), their immunity being largely due, no doubt, to the well-known idiosyncrasies of the negro race, as diseases of this class were much more frequent when white troops formed the garrison."

Of 19,120 cases of disease of all kinds recorded at sixteen military posts in Texas during four years, 1870–1874, 77, or 1 in 248.2, were for consumption. The most prevalent diseases were malarial fevers and diarrhœal diseases. The largest proportion occurred at Fort Clark, Kinny County, latitude 29° 17′ north; longitude 23° 18′ south; approximate elevation above the level of the sea, 1,000 feet; where, out of 1,509 cases, 846 white and 661 colored, there were of consumption 14 cases, 6 white and 8 colored. The site of this post is a rocky ridge of limestone, embraced in a curve of Las Moras Creek, which issues from the Las Moras Spring—a sort of pond about one-eighth of an acre in area—400 yards north of the post. The prevailing winds are east-southeast. When the wind varies in force and direction, it is always the premonition of a "norther," which occurs about once every ten days during the winter season, *i. e.*, from the beginning of November to the end of March. During these northers, the wind usually blows with great violence from the northwest, north, and northeast, but most severely from the northwest, during which it is impossible to travel over the plains; in summer they are less frequent and not so violent.

Of 13,270 cases of disease of all kinds recorded in the military posts of Georgia, Alabama, Mississippi, and Louisiana during four years, 1870–1874, 51, or 1 in 260 were for consumption. The most prevalent diseases in these posts for the period were intermittent fever and diarrhœal diseases.

Several mineral springs are said to exist in Florida: At *Green-Cone*, Clay County, accessible by steamboat on St. Johns River, from Jacksonville, contains sulphates of magnesia and lime, chlorides of sodium and iron; *Orange Spring*, Marion County, near Ocklawaha River; *Senvance Springs*, Hamilton County, on Savannah, Florida, and Western Railroad, the water has strong sulphurous odor, which soon passes off when the water is collected, and then it is palatable; *Tarpon Spring*, Hillsboro County, sixty miles from Cedar Keys, said to contain sulphur, soda, lime, and salt; and there are several others, but none of them have been analyzed.

Bladon Springs, Choctaw County, Alabama, Bladon landing, on the Tombigbee River, by steamboat from Mobile, situated in a salubrious pine-forest region, are *alkaline* and *sulphur*.

One pint contains.	Vichy Spring, 67° F. J. L. & W. P. Riddell.	Branch Spring, 67° F. J. L. & W. P. Riddell.	Ola Spring, R. T. Brumby.	Sulphur Spring, J. L. & W. P. Riddell.
SOLIDS.	Grains.	Grains.	Grains.	Grains.
Carbonate of soda	5.791	5.151	4.111	4.367
Carbonate of magnesia	0.036	0.076	0.170	0.081
Carbonate of iron	0.062	0.029	.....	0.095
Carbonate of lime	0.109	0.267	0.344	0.302
Chloride of sodium	.....	.....	0.962	.....
Sulphate of lime	0.282	0.349	0.002	0.370
Sulphate of iron	.....	.....	0.030	.....
Sulphate of manganese	trace	.....	....	trace
Silica and alumina	.....	.....	0.263	.....
Crenic acid	....	.....	0.091	.....
Hypocrenic acid	.....	.....	0.075	.....
Organic matter	0.282	0.237	.....	0.156
Loss	.....	.....	0.040	.....
Total	6.562	6.112	6.088	5.371
GASES.	Cubic in.	Cubic in.	Cubic in.	Cubic in.
Carbonic acid	8.18	7.40	4.07	6.61
Sulphuretted hydrogen	trace	trace	undetermined	0.07
Chloride	0.23	0.23	.....	0.23

Blount Springs, Blount County, Alabama, 1,580 feet above the level of the sea, accessible by railroad from Montgomery to Decatur, about 85 miles northwest from Montgomery:

One pint contains.	Red Sulphur. Prof. R. Brumby.	Sweet Sulphur. Prof. R. Brumby.
SOLIDS.	Grains.	Grains.
Carbonate of magnesia	0.55	0.45
Carbonate of iron	0.24	0.14
Carbonate of lime	0.85	0.56
Chloride of sodium	4.04	3.86
Chloride of magnesium	0.75	....
Sulphate of magnesia	0.20	0.30
Total	6.63	5.31
GASES.	Cubic inches.	Cubic inches.
Carbonic acid	0.75	0.75
Sulphuretted hydrogen	1.87	1.57

Valhemosa Springs, Morgan County, Alabama, by steamboat on Tennessee River, said to be sulphur and chalybeate. No analysis.

Cooper's Well, Hines County, and *Ocean* Springs, Jackson County, Mississippi, on New Orleans, Mobile, and Texas Railroad, are both held in high esteem by those who are best acquainted with them. The first, as *chalybeate,* with mild purgative qualities, said to resemble the waters

of Bocklet Springs, near Kissingen, Bavaria. One pint contains (50° F., Prof. J. Lawrence Smith):

Solids.	Grains.
Chloride of sodium,	1.045
Chloride of magnesium,	0.435
Chloride of calcium,	0.540
Sulphate of potassa,	0.076
Sulphate of soda,	1.463
Sulphate of magnesia,	2.910
Sulphate of lime,	5.265
Sulphate of alumina,	0.765
Peroxide of iron,	0.420
Crenate of lime,	0.039
Silica,	0.225
Total,	13.183
Gases.	Cubic in.
Carbonic acid,	4.0
Oxygen,	1.5
Nitrogen,	4.5

Ocean Springs: One pint contains (J. L. Smith):

Solids.	Grains.
Chloride of potassium,	trace.
Chloride of sodium,	5.971
Chloride of magnesium,	0.621
Chloride of calcium,	0.485
Protoxide of iron,	0.589
Iodine,	trace.
Alumina,	trace.
Organic matter,	trace.
Total,	7.666
Gases.	Cubic in.
Carbonic acid,	1.22
Sulphuretted hydrogen,	0.16

In Louisiana, it is said that within a radius of thirty miles from Mansfield are several valuable sulphur and chalybeate springs. *De Soto* Springs, at Mansfield, forty miles by stage from Shreveport, on the Red River, and *White Sulphur* Springs, twenty-five miles by stage from Alexandria, on the Red River, are described as excellent sulphur waters, with saline ingredients, useful in biliary engorgements. No analysis. These springs are well situated in the upland pine-wood region.

Fairview Springs, near Kassee, Limestone County, Texas, have recently been brought to notice. One pint contains (Prof. C. F. Chandler):

Solids.	Grains.
Chloride of sodium,	0.220
Sulphate of soda,	0.706

	Grains.
Sulphate of magnesia, ...	1.228
Sulphate of lime, ...	0.163
Alumina and its sulphate, ...	0.675
Phosphate of iron, ...	0.257
Total, ...	3.249

Piedmont Springs, in Grimes County, and *White Sulphur* Springs, in Cass County, Texas, have been reported, but without analysis.

Except the mountainous region of Alabama, there are no elevations in the southern portion of the Gulf States more than a thousand feet above the Gulf; and except the salutary influence of the forests, there are no natural conditions which exercise any influence over the climate beyond the ordinary effects of latitude.

In the piny uplands, however, and particularly in the northern part of Alabama, through which the Blue Ridge Mountains extend, though not to a very great height, and away from the low, dark bottom lands of the coasts and water courses, the climate of this region is generally healthy.

Arkansas has great variations of surface. In the western and northwestern portion of the State there are extensive elevated prairies, broken by the passage across them of the Ozark Mountains in a northwesterly direction, from Little Rock to Southwestern Missouri, and, south of the Arkansas River, of the Massern range. The hills of Ozark range rise to a general elevation of 1,500 to 2,000 feet, with summits of 3,000. And besides these, two ranges called the Black Hills and Wachita Hills in the west, varying from a few hundred to a thousand feet in height, with intervening valleys across the rich prairies and luxuriant forests, give the State a diversity of scenery remarkably beautiful, and a climate, on the whole, of exceptional salubrity. An eastern portion, from twenty to one hundred miles west of the Mississipi, is an exception. This is generally low, contains numerous small lakes and swampy bayous, and is unhealthy.

Indian Territory is, for the most part, low, swampy, and unhealthy. The northwest corner, through which the Wachita range of mountains extends about fifty miles, is somewhat exceptional, and relatively salubrious, approaching the far more salubrious climate in general of northern Texas.

The surface of Missouri, in its southern portion, partakes somewhat of the character of the adjacent region of Arkansas. Excepting this, there are no elevations above a thousand feet. The surface is generally rolling and level prairie, with occasional forests. The southeastern portion, which is subject to frequent overflow by the Mississippi and its tributaries, is low and swampy, and insalubrious. Otherwise, there are no special surface characteristics that exercise any influence over the

climate beyond what may be learned by reference to the charts and tabulated data on other pages.

Texas highlands are among the most salubrious regions in the country. In the vicinity of Fort McKavett, situated on the right bank of the San Saba River, about two miles from its source, latitude 30° 50′ north; longitude 23° 17′ west; altitude 2,000 feet: Assistant Surgeons R. Sharpe and S. M. Horton, U. S. Army, report:[1]

"The dryness of the atmosphere, the delightful breezes of the morning and evening throughout the latter part of the spring, the entire summer and fall, the middle portion of the days during a great part of this time being excessively warm, and the sunlight excessively bright, which, with the dry winds blowing incessantly, tries the eyes to the utmost when out of doors; the pure, fresh drinking water from a most excellent spring, bubbling up at the foot or base of the bluff, just west of the post, through limestone rock of indefinite thickness, and in consideration of the very favorable reports of former years as to the small amount of sickness occurring in this vicinity: these have all combined to give this post and locality the name of being exceedingly healthy."

From Fort Stockton, on the line of the great Comanche trail, latitude 35° 50′; longitude 25° 35′; altitude 4,850 above sea-level. Assistant Surgeons P. J. A. Cleary and E. Alexander, U. S. Army, report:[2]

"The beneficial effects on the atmosphere and climate on pulmonary affections, and particularly on phthisis pulmonalis, cannot be too highly extolled. The atmosphere is warm, dry, and pure. Many people come to the State to have their 'consumption' cured, but generally arrive when the disease is too far advanced, and, moreover, do not come far enough west."

The climate of Kansas, at an altitude of 3,320 feet above the level of the sea, latitude 38° 55′ north; longitude 23° 47′ west, as reported by Assistant Surgeons M. M. Shearer and F. H. Atkins, U. S. Army:[3]

"It is of great salubrity and dryness. Snow falls rarely, and in small quantity, seldom lying more than a day or two. High winds are common, and frequent gales of alarming force often blow for many hours. During the warm months, the direction of the winds is from the south and east, and this is reserved during cold weather. Malarial diseases do not originate here; all cases having their origin elsewhere. No scurvy, pneumonia, pleuritis, or phthisis had occurred during 1872 or 1873, and but six cases of dysentery were treated in that time. Influenza has also been very rare."

Climax Springs, Climax, Camden County, Missouri, on Missouri Pacific Railroad, have recently attracted a good deal of attention on

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[1] Op. cit., pp. 217, 240.

[2] Op cit., p. 240.

[3] Fort Wallace. Op. cit., p. 307.

account of the extraordinary proportion of the iodides and bromides contained in the water.

One pint contains (H. W. Wiley)

SOLIDS.	Grains.
Carbonate of lime,	0.651
Chloride of sodium,	4.451
Sulphate of lime,	0.707
Iodide and bromide of potassium,	0.319
Iodide and bromide of magnesium,	1.250
Oxide of iron, alumina, and silica,	1.000
Organic and undetermined,	0.424
Total,	8.802

Carbonic acid, 3.45 cubic inches.

This spring is in a cave in the Ozark Mountains, about 1,000 feet above the level of the sea, and consists of a basin about twelve feet in diameter, without any known outflow. Further explorations and repeated analyses are necessary to determine its character.

Montesana Springs, Jefferson County, twenty miles south of St. Louis, on the Iron Mountain Railroad, are *saline sulphur* waters, resembling the Blue Lick Springs.

One pint contains (60° F. Profs. Potter and Riggs):

SOLIDS.	Grains.
Carbonate of magnesia,	1.756
Carbonate of lime,	8.931
Chloride of potassium,	2.046
Chloride of sodium,	45.638
Chloride of magnesium,	4.488
Sulphide of sodium,	0.042
Hyposulphite of soda,	0.093
Sulphate of lime,	4.046
Phosphate of lime,	trace
Iodide of magnesium,	0.106
Bromide of magnesium,	trace
Iron and alumina,	0.108
Silica,	0.063
Total,	67.317
GASES.	Cubic inches.
Carbonic acid,	5.80
Sulphuretted hydrogen,	0.17

Sweet Springs, Saline County, Mo., one mile from Brownsville, on Sedalia and Lexington Branch of the Missouri Pacific Railway, are also *saline-sulphur.*

One pint contains	Sweet Spring. C. P. Williams.	Arkesian Spring. C. P. Williams.
SOLIDS.	Grains.	Grains.
Carbonate of iron	0.070	0.033
Carbonate of magnesia	trace	0.025
Carbonate of lime	1.192	5.031
Chloride of potassium	0.424	3.570
Chloride of sodium	11.298	94.514
Chloride of magnesium	2.786	10.914
Chloride of calcium	1.840	9.349
Chloride of lithium	0.006	0.036
Sulphide of sodium	....	0.326
Sulphate of calcium	1.182	7.242
Sulphate of baryta	....	0.019
Phosphate of calcium	....	0.030
Bromide of magnesium	0.014	0.016
Nitrate of magnesium	....	0.022
Nitrate of ammonium	....	0.021
Alumina	0.011	0 021
Silica	0.135	0.064
Organic matter	0.506	0.380
Total	19.460	131.613

St. Louis Artesian Well is a good saline water. One pint contains (73° F. Dr. Litton):

SOLIDS.	Grains.
Carbonate of magnesia,	0.127
Carbonate of protoxide of iron,	0.066
Carbonate of lime,	1.329
Chloride of potassium,	1.126
Chloride of sodium,	43.826
Chloride of magnesium,	4.792
Chloride of calcium,	3.448
Sulphate of lime,	5.709
Silica,	0.017
Total,	60.440
GASES.	Cubic inches.
Carbonic acid,	0.82
Sulphuretted hydrogen,	0.03

In Arkansas, the *Hot Springs*, in Garland County, Hot Springs Station, on St. Louis, Iron Mountain and Southern Railroad, are of world-wide repute. One pint contains (93°–150° F.):

SOLIDS.	Grains.
Carbonate of magnesia,	0.016
Carbonate of lime,	0.496
Chloride of sodium,	0.001
Sulphate of potassa,	0.029

	Grains.
Sulphate of soda,	0.047
Sulphate of lime,	0.014
Sesquioxide of iron,	0.013
Iodine,	trace
Bromine,	trace
Silicate of lime,	0.058
Silica,	0.233
Alumina,	0.056
Organic matter,	0.088
Water,	0.018
Total,	1.069

These springs are very extensive, fifty-seven in number, situated in a valley on the western slope of the Hot Springs Mountain, a spur from the Ozark Mountains, thirteen hundred and sixty feet above the level of the sea. The baths are very elaborately appointed, and they are deservedly esteemed in the treatment of chronic rheumatism and gouty diseases, and tertiary syphilis.

Ravenden Springs, Randolph County, twenty-eight miles by stage from O'Kean, a station on St. Louis, Iron Mountain and Southern Railroad, are valuable *alkaline* waters, containing so large a proportion of carbonic acid as to render them exceptionally palatable. One pint contains (Wright and Merrell):

Solids.	Grains.
Carbonate of magnesia,	0.560
Carbonate of lime,	0.576
Carbonate of lithia,	0.157
Chloride of sodium,	0.273
Chloride of magnesium,	0.373
Chloride of lime,	0.155
Sulphate of lime,	trace
Sulphate of alumina,	0.295
Silica	0.103
Iodine and iron,	trace
Organic matter,	0.232
Total,	2.724
Gases.	**Cubic inches.**
Carbonic acid	2.68
Atmospheric air,	1.66

Eureka Springs, in Carroll County, have also attracted some attention. A published analysis shows that the water contains only 0.483 grains of alkaline substances to the pint, and leads to the inference that it is similar to that of Summit Spring, in Maine, chiefly valuable, if of any value at all, for its negative qualities only.

CHAPTER XVII.

CLIMATOLOGICAL TOPOGRAPHY AND MINERAL SPRINGS OF THE WESTERN HIGHLANDS.

THE arid and sandy surface of the western slope of the Rocky Mountains, with its climatological associates of variable temperature and exceeding dryness of the atmosphere, begins at the 100th meridian, about two thousand feet elevation above the level of the sea, and follows the general trend of the mountains northwesterly to the 113th meridian, from the southern to the northern boundary of the United States.

Sandy and saline tracts of various dimensions are interspersed over all this region, yet with the exception, perhaps, of one in Utah, none of them are of an extreme desert or basin character.

Of the physical geography of the Rocky Mountains, Blodget remarks[1] that:

"The most important point in the vertical configuration of the region is its plateau character, or the great altitude of the base-line from which the mountains rise and the valleys fall. In this sense, the average of the whole continent west of 102° of longitude might be taken as on a base of five thousand feet above the sea, excepting only the immediate coast of the Pacific and the deeper valleys of California. A better division would be to take the Rocky Mountain plateau at six thousand feet, and that of the great basin at four thousand; still throwing out some exceptional districts at the extreme points north and south. The Rocky Mountain plateau is best defined at the vicinity of the South Pass, yet it extends from Fort Owen to El Paso, with an average breadth of five degrees of longitude at least; more correctly, perhaps, an average of two hundred and fifty miles. In latitude it is nearly one thousand miles in extent, giving an area of two hundred and fifty thousand square miles for this lofty plateau. The short mountains interrupt these irregularly, rather than regularly, and the characteristic formation is one of single peaks rather than chains of mountains, and few of these peaks reach up to snow-line.

"The highest plateau may be distinctly recognized both north and south of the Wind River Mountains in latitude 44° and 45°, forming

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[1] Op. cit., p. 88.

there a sage-plain desert at the sources of the Jefferson's and Madison's Forks of the Missouri; and at the sources of Snake River, north of Fort Hill, a similar desert plain occurs, at least equally elevated. Passing some rough country north of these, another great plain, extending from Larime to Grand River, is described by Fremont, Stansbury, and others. The valley of San Luis, in Northern New Mexico, is another nearly desert area, notwithstanding its great altitude of nearly eight thousand feet.

"The parks, though more fertile, belong to the same category of lofty plains, and southward along the Rio Grande, the chain of these divides, and they pass at each side, retaining the same characteristics to Fort Webster and the Gila at the west, and nearly to the Rio Grande to El Paso on the east. Whatever doubt there may be in assigning a place in the Rocky Mountain system to the mountains of New Mexico west of the Rio Grande, either as a principal chain or as a bifurcation, there can be no doubt of this connection of plateaus. Both branches fall off in altitude to three or four thousand feet at the terminal points named, though that of the Sierra Madre on the west extends some distance toward the Colorado River, forming the Grand Cañon, in regard to which little is positively known beyond this general fact.

"At the highest point of this district only, or at the mountains in the vicinity of the *Parks*, described by Fremont, in 39° north latitude, and at the Wind River Mountains, in latitude 43°, the peculiarities, better described as 'Alpine,' are developed—the snow and ice remaining late, with the verdure and freshness belonging to high mountains in Europe in summer."

Fremont's graphic description of the region of the Great Parks, forty years ago,[1] gives a better idea of its general features than any which has ever been given since, as follows:

"The valley narrowed as we ascended, and presently degenerated into a gorge, through which the river passed as through a gate. We entered, and found ourselves in the New Park—a beautiful circular valley of thirty miles diameter, walled in all round with snowy mountains (June 14th), rich with water and with grass, and fringed with pine on the mountain sides below the snow line. Latitude 40° 52′ 44″; elevation by the boiling point, 7,720 feet.

"It is from this elevated cove, and from its gorges of the surrounding mountains and some lakes within their bosoms, that the great Platte River collects its first waters.

"June 17th, we fell into a broad and excellent trail made by buffalo, where a wagon would pass with ease, and, in the course of the morning, crossed the summit of the Rocky Mountains, through a pass which was one of the most beautiful we had ever seen. The trail led among

[1] "Senate Reports of Explorations in 1842, '43 and '44," p. 282.

aspens, through open ground richly covered with grass, and carried us over an elevation of about 9,000 feet above the level of the sea.

"The Old Park is more or less broken into hills, and surrounded by the high mountains, timbered on the lower parts with quaking asp and pines. On the 20th June, a piny side of mountains, with bare rocky peaks, was on our right all day, and a snowy mountain appeared ahead. At the camp, by the temperature of boiling water, our elevation was here 10,430 feet; and still the pine forest continued, and our grass was good. On the 21st, in a ride of about three-quarters of an hour, and having ascended perhaps 800 feet, we reached the summit of the *dividing ridge*, which would thus leave an estimated height of 11,200 feet. Immediately below us was a green valley, through which ran a stream, and a short distance opposite rose snowy mountains, whose summits were formed in peaks of naked rock." This was *South Park*, on the sources of Arkansas River.

"Very much the greater portion of the Rocky Mountain district," says Blodget,[1] "is one of plateaus in its surface character, and in its consequences in every respect, sandy, and treeless, and saline, in alternating tracts, interspersed, of course, with others essentially different and with rich valleys. Thus the valley of the Rio del Norte, which is the first in succession from the south, is in parts rich, and in others desert or basin-like, as the Bolson de Mapimi, and the basin of Lake Guzman, both on the south and in Mexico; the Iomado del Muerto of the Rio Grande Valley, in New Mexico, and the sand desert of the Peco, River; the sand hills and sandy plain of San Luis, in the extreme north of New Mexico, at an altitude of 8,000 feet; the dry Larime plain at 5,000 feet; the high desert plain, north of Fort Hall, at 5,000 to 6,000 feet; and the Sage desert, on the east of the central range of the Rocky Mountains at the sources of the Missouri, Jefferson's Fork, etc. All these points are no less characteristic of the surface and configuration of the Rocky Mountain district than the peaks and Alpine features of the district of the Parks, and of the Wind River Mountains themselves. West of this district lies a great homogeneous area of basins, merging at the south into the basins of Mexico, enumerated above. Though drained by three large rivers, or traversed by them rather, since they get most of the waters beyond it and very little in it—the Columbia, Colorado, and Gila—it is essentially an undrained region, or one sending no water to the sea. Nearly all its surface is studded with minor basins, the principal one of which is Great Salt Lake. Next is that of Humbolt River, and north and south of these an immense area possesses characteristics of great uniformity, the chief of which are an arid climate and a barren surface. Sandy and saline tracts, salt lakes and marshes; mésas, or high and abrupt plateaus of small extent, without wood and

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[1] Op. cit.

deficient in all forms of vegetation; unaltered volcanic districts and rough, abrupt mountains make up most of the American basin region.

"The central portion in latitude is near the 40th parallel, and at an average of 4,500 feet above the sea the northern extremity declines at the 48th parallel to 700 or 800 feet in the lower part of the great plains of the Columbia River, which form a climatological basin. At the south, the altitude falls off to sea level without changing its climatological character as a basin, and this decrease of altitude passes through several minor basins; in fact, that of the Mojahve River, being one of the principal now known, and not much above the level of the Colorado River, while still another tract, west of the Colorado and further south, is at or below sea level.

"The area occupied by this basin region is much greater than that of the great mountain plateaus; and if the bordering mountains on the west are included, embracing all the country at once elevated and arid west of the greater altitudes before described, the area can scarcely be less than five hundred thousand square miles, of which the average altitude is 3,500 to 4,000 feet. The sum of this and the first district—seven hundred and fifty thousand square miles—expresses very forcibly the immensity of this feature of configuration; and it is more essential to bear it in mind in the consideration of climates than all that relates to single mountain ranges. And climates with great extremes of temperature, and with the most complete interruption of symmetry in their changes, and the predominance of the local character in every respect, necessarily follow from this configuration."

Bearing in mind the general effects of latitude and altitude, taken in connection with other meteorological records of the Signal Service given on previous pages, and the foregoing sketch of the surface characteristics of this region, it would be difficult to reconcile practical conclusions with such descriptions of the climate of the Western Highlands as are frequent in current literature, based upon transient observation and insufficient knowledge of the physical effects.

"From an experience of fourteen months, and upon natural grounds," observes Surgeon A. K. Smith, U. S. Army,[1] "I cannot coincide in the popular belief that Santa Fé (altitude, 6,850 feet above the sea; latitude, 35° 41′ north; longitude, 28° 29′ west), and the contiguous localities of equal or superior altitude are well adapted as a residence for persons suffering with pulmonary tuberculosis, heart disease, or any cause producing obstruction to free and ample respiration. The universal testimony is, so far as I can ascertain, that a stranger to the rarefied atmosphere, however sound his circulatory and pulmonary organs may be, is almost invariably affected by a great oppression in respiration upon his advent into this elevated country, accompanied naturally by an un-

[1] Op. cit., p. 293.

wonted lassitude and indisposition for exertion. There have been, in the case of two or three of my acquaintances, ugly symptoms of a partial paralysis of the organs of locomotion and speech. A continued residence, however, is said to overcome these unpleasant effects in persons of sound and robust health; and from the number of Americans and Germans residing in the higher regions of New Mexico, who transact their business at no small expenditure of physical exertion, I believe this to be the case, and that in time an accommodation obtains between the lungs and the somewhat diminished quantity of oxygen.

"As regards the invalid whose breathing apparatus is crippled by tubercular deposit, by chronic pneumonia, or whose blood, whatever may be the cause, requires full aëration, I deem it worse than useless for him to endeavor to regain health or even comfort in such localities. I regard my lungs (and my chest measurement is forty-four inches) as perfectly sound, and yet after reporting for duty in Santa Fé I could not, as a general rule, breathe comfortably, although at times, when a damp atmosphere prevailed, I could not notice any impediment to respiration. The past summer (1874) was exceptionally warm, and I was at intervals asthmatic to a terrible degree, crushed actually by a feeling of impending dissolution. The common advice to me was 'wear it out; you will be all right next year.' No sooner, however, had I started East than my troubles, as I descended in altitude, lessened proportionally."

From Fort Union, with an altitude of 6,700 feet, 100 miles distant from Santa Fé, situated in a narrow valley on the eastern slope of the Rocky Mountains, Assistant Surgeon, W. H. Gardner, U. S. Army, reports:[1]

"Wind from some quarter is almost constant, and the soil being light and sandy, is blown about in clouds of blinding, suffocating dust that irritates the air-passages, and is the prevalent cause of catarrhs, pharyngitis, and bronchitis.

"The diurnal variation in temperature is very great, the thermometer frequently showing at 6 A.M. but 60°, and at 2 P.M. showing 90°; even in midsummer nights one or more blankets are always comfortable to sleep under. Now from the foregoing causes, namely: the high elevation, the constant winds, the suffocating dust storm, and the great diurnal variations in temperature, I do not believe this post *can* be favorable for any kind of lung disease; and though my medical experience here is limited, I believe it will point to the same conclusion.

"Shortly after arriving at the post, I was attacked with a fulness of the head, ringing in the ears, mental hebetude and confusion of ideas, dizziness and headache. Thinking these symptoms might be caused by constipation, dyspepsia, or torpidity of the liver, I took a mercurial purga-

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[1] Op. cit., p. 303.

tive, and followed it up with a dose of Rochelle salts, which relieved the fulness of oppression for a day or two, but it at once returned; the dizziness and confusion of ideas increased, and a feeling of numbness and tingling commenced in the fingers of the left hand, and gradually spread until it involved the whole left side, even the muscles of the tongue being involved in the paralysis, so that I could not articulate. There was also oppression of the breathing, throbbing of the carotids, and slight dilatation of the pupils. The only medicine handy at the time of the first attack was a bottle of chloroform; and thinking the symptoms might be due to spasms of the cerebral or pulmonary veins, I poured a drachm or two on my handkerchief and inhaled it, when the disagreeable symptoms promptly subsided. The next day, on my visit to Dr. Moffatt, of our corps, I told him of my troubles, and he thought they were due to malarial poisoning, and advised me to commence a course of quinia and arsenic, which I at once did, taking twelve grains of quinia and one-tenth of a grain of arsenic each day. But in the course of five or six days, while under the full influence of these medicines, I had another attack in all respects similar to the first, coming on after a hearty dinner, which was relieved by a prompt emetic. Shortly after this second attack, I was sent for to attend a case of midwifery at Mora (a little town in the mountains, fifteen miles northwest of the post, and about four hundred feet higher in altitude), and while there alone I had another attack more severe and prolonged than the other two; and upon this occasion I certainly thought there would be another vacancy in the Medical Corps to fill, for I took emetics, bromide of potassium, and chloroform ad nauseam without the least effects. The symptoms went off before morning, but when I got back to the post I brought the Darwinian theory to bear on the case. *Ita:* If the environment of an animal be suddenly changed, and the animal does not change its habits to suit its environment it will be speedily eliminated. The only radical change in environment I could detect here was decreased atmospheric pressure from increased altitude, and consequently deficient oxygenation of the blood. The indication, therefore, was either to supply the deficiency of oxygen to the blood, or to reduce the volume of blood to the decreased amount of oxygen. The alternative seemed to be the easiest and the most certain. I, therefore, decreased the amount of my nitrogenous food, and made up the quantity by laxative vegetables and fruits, and have been in good health ever since. I have seen two cases since, in every respect similar to mine, and they have promptly succumbed to the treatment indicated; that is, decreasing the amount of blood to the decreased amount of oxygen, by cathartics and decreased animal food."

From Fort Selden, situated in a sandy basin one and a half miles from the Rio Grande, in southern New Mexico; latitude, 32° 35′ north; lon-

gitude, 30° west; height above the sea about 4,250 feet. Assistant Surgeon Samuel S. Jessup, U. S. Army, reports:[1]

"Lung troubles are comparatively rare, as are all diseases of the respiratory organs, excepting catarrh, which I prefer to consider separately from bronchitis, as it mostly affects the mucous membranes of the nose, tonsils, and larynx, and, I think, seldom extends even to the trachea. It seems to be produced by the almost constant drifting of the irritating dust peculiar to this region, and few new-comers who are much exposed in the open air escape it. It gradually wears off as they become acclimated. Women, from their indoor habits, are usually free from it. The native New Mexicans are not at all affected by it. Many of them, however, suffer from a form of bronchitis induced, it is thought, by their peculiar fashion of smoking the cigarette, *i. e.*, by inhaling the smoke into their bronchial tubes, and exhaling it through their nostrils.

"The climate of this part of the Rio Grande will improve, and probably tend to the cure of many patients affected with commencing phthisis, but only by a residence here, not by a sojourn of a few months. I think I am within the mark in stating that it will take from eighteen months to two years to acclimate them. To those in advanced stages no such benefit can accrue."

From Fort Wingate, situated in latitude 35° 20′ north; 31° 22′ west; altitude, 6,822 feet, 208 miles distant from Santa Fé via Albuquerque, Assistant Surgeons R. S. Vickery and J. V. De Hanne, U. S. Army, report:[2]

"The climate dry and equable; breezy and pleasant in the hottest weather. There are no very high winds except in March. Average difference between the wet and dry bulb thermometer in summer, 10.59°; in winter 4.43°. In March and April there are occasional high dry winds from southwest and west, bringing much dust with them and going down generally at sunset. The nights are nearly always calm."

Fort Bayard, situated in almost the extreme southwestern corner of New Mexico; latitude, 30° 40′ north; longitude, 31° 25′ west; altitude, 6,022 feet. Distance about eighty miles from Janos, the nearest settlement to the Mexican frontier. Of this region, Assistant Surgeon William J. Wilson, U. S. Army, reports:[3]

"On the north, northwest, and east, the post is surrounded by high mountains open on the south and southeast. Pine, cedar, and oak are found in large quantities on the surrounding hills. The climate is delightful, but there is very little rain, except during the rainy season, which lasts from about the end of June until the middle of September,

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[1] Op. cit., p. 296.
[2] Op. cit., p. 311.
[3] Op. cit., p. 246.

when more or less rain falls nearly every day, sometimes in torrents. The winds are generally from the west, northwest and south, and seldom severe. Changes in temperature are very gradual. On account of the altitude of the post and the dryness of the atmosphere, the heat of summer is never oppressive, while the nights are always deliciously cool. The winter season is very mild, one or two light falls of snow occurring generally in February and lasting but one or two days.

"In bronchitis, either acute or chronic, this climate is unfavorable for either cure or relief. The air is too rarefied and too stimulating, and acts almost as an irritant to the bronchial mucous membrane. I have also observed in even slight cases of catarrh attended with cough, that they are very intractable. I have seen several cases of phthisis, and have one at the present time under my charge, but I have not seen any beneficial results produced by this climate. They have all gone on from bad to worse, and finally died. I believe that it is only the very early stages of tubercular disease that this or any other climate can exert a beneficial influence.

"I have a theory of my own in regard to the disease, and which I believe I have seen exemplified by several cases; and that is, that there are, so to speak, two classes of cases, one of which is characterized or accompanied by a dry, hacking cough, but with little expectoration and a tendency to hæmoptysis. In the other, there is a copious secretion from the bronchial mucous membrane. This latter class would be benefited by a mild dry climate, not subject to sudden changes, and of a lower altitude than this, say 2,000 or 3,000 or 4,000 feet. The former class would lead a life of torture here, and this climate, or one similar to it, would only add to the mischief already done. They would be benefited by a mild moist climate, in close proximity to the sea. Phthisis is almost unknown among the Mexican population here, notwithstanding their filthy habits, probably on account of their living nearly all the time out of doors, and being natives of the soil and accustomed to this climate. I know that horses brought here from the States, and cattle introduced here go down in condition for the first year until they are acclimated, and I believe that the human race requires also a certain time for acclimation."

Of 4,728 cases of disease from all causes recorded at the military posts in New Mexico during four years, 1870 to 1874, 10, or one in 472.8, were for consumption. The most prevalent diseases at these posts during the while were diarrhœa and catarrhal diseases, and intermittent fever.

In Arizona, from Camp Apache, at the altitude of 6,000 feet above the sea, latitude, 33° 40′; longitude, 32° 52′ west. The climate is described by Assistant Surgeons J. B. Girard and L. G. Loring[1] as

[1] Op. cit., p. 525.

being cool and moist, as compared with that of the lower districts. The forests are extensive, and the plateaus and river bottoms during the rainy season are luxuriant with rich grasses. Of 1,171 cases of diseases at the post, during the period 1870–74, there was one only of consumption. There were 446 cases of intermittent fever.

At Camp Grant, in the southern part of Arizona, latitude 32° 25′ north; longitude, 32° 23′ 10″ west; altitude, 3,985 feet above sea level, Assistant Surgeon G. McMiller[1] describes the climate as an eminently disagreeable one. "The warm season is very protracted and the days very hot. The nights, however, are comparatively cool; otherwise the heat would be absolutely insupportable. The winters are mild, almost as much so as those of Florida; but violent winds, frequent at all seasons, are particularly prevalent during the cool portion of the year, and very heavy rains are also then frequent, especially during the months of January and February. There are, however, occasional periods of pleasant and even charming weather, especially during the autumnal months. The mildness of the winters is fortunate for the military, preventing much discomfort to imperfectly-sheltered officers and men. The climate lacks equability at all seasons. The thermometer may indicate, in winter, a point below freezing at day-break, and the cold may be very uncomfortable, while at 2 o'clock P.M. of the same day a thin coat may prove unpleasantly warm to the wearer. Notwithstanding the mildness of the winters, the frequent and great variations of temperature will always render the climate an unsuitable one for phthisical invalids. Catarrhal affections, of every grade of severity, are exceedingly common."

At Camp McDowell, situated on the Rio Verde about eight miles above its junction with the Salt River, latitude, 33° 40′ north; longitude, 34° 37′ west; altitude, 1,800 feet above the sea: "The climate is warm and dry. Although the thermometer in the day-time in summer may show a high degree of heat, the nights are commonly not oppressive. Thunder clouds from the mountains drop a heavy passing shower once a month. In winter the rains are lighter, though of much longer duration. Snow falls on the mountains, but not on the mesa. The winds are variable and light, except when immediately preceding a thunder storm."[2]

At Camp Mojave, situated on the Colorado River, near the head of the Mojave Valley, latitude 35° 6′ north; longitude 37° 28′ west; altitude, 600 feet above the level of the sea. "The climate is healthy, the winters pleasant, but the summers extremely hot. There is no rainy season, though thunder showers are frequent in July and August. The annual rise of the Colorado takes place in June. The prevailing winds in the

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[1] Op. cit., p. 535.

[2] Assistant Surgeons Charles Smart, D. De Witt, and James Reagles, U. S. Army. Op. cit., p. 544.

summer are from the south, and passing over the arid plains the air is so heated that its scorches like that from an oven. The nights are as hot as the days, the temperature not varying in the slightest degree for hours—so hot that no one can sleep in a house, the whole garrison lying upon the open plain, endeavoring to catch the faintest breeze, the walls of the houses becoming so heated as to render the barracks unendurable.[1] Of 335 cases of disease recorded in four years at this post, 1870–1874, five were for consumption.

"In the valley of Granite Creek (at the base of Granite Mountain near the northern extremity of the Sierra Prieta, latitude 34° 29′ 6″ north; longitude 35° 27′ 30″ west); during the spring and summer months, the climate is mild; there being none of the long and scorching heat which in the southern portion of the territory kills all vegetation except that on the margin of the streams. Frequent rains fall in the autumn, and during the winter the mountains are covered with snow, which in the severe seasons may lie even in the valleys for two or three weeks at a time."[2]

Of 9,121 cases of disease recorded at nine military posts in Arizona during four years, 1870–1874, 19, or 1 in 480, were for consumption. The prevailing diseases were intermittent fevers, catarrhal and diarrhœal diseases.

The climate of Southern Colorado is reported upon by Assistant Surgeon P. Moffatt, U. S. Army,[3] from Fort Garland, situated at San Luis, the southern of the Colorado Parks; latitude, 27° 23′ north; longitude, 27° 20′ west; altitude, 7,805 feet above the sea.

Dr. Moffatt observes that:—

"In the last few years this region has acquired quite a degree of notoriety as a sanitarium for persons suffering from various forms of chronic disease—more particularly in cases involving pulmonary affections. Great numbers of invalids come to this territory yearly from the Atlantic States, and many from foreign countries in search of health. This region promises fair to become to health-seekers the Italy and Switzerland of the American Continent, and the Rocky Mountains to vie with the Alps and Appenines as a resort for those in search of a new lease of life.

"In considering the sanitary effects of a sojourn or permanent residence in this country, including not this point only, but all the elevated regions of the southwest, two distinct points are to be taken cognizance of : one is the change in occupation, manner of life, and social relations to which the individual is introduced, and which he is led to adopt

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[1] Assistant Surgeons F. S. Stirling and J. B. Lawrence, U. S. Army, Op. cit., p. 547.

[2] From Fort Whipple, Assist. Surgeons H. R. Lippincott and J. B. Girard, U. S. Army. Op. cit., p. 556.

[3] Op. cit., p. 257.

upon arriving in this country; the other has reference to climatic and other conditions peculiar to the locality to which he is subjected.

"In the case of the tourists travelling for pleasure or for health, the drudgery of business has been suspended, and recreation is made the object of life for the time; or the indolent and luxurious life of the city has been exchanged for the novelties, exercise, and less sumptuous fare of "the mountains." In the case of those who have settled permanently in the country, they too have adopted occupations and habits of life materially different from what they were accustomed to before coming here. It is quite a usual thing in these mountainous regions to find people living a pastoral life, or prospecting for ledges amidst the modest surroundings, and in the most primitive style, who had been reared in affluence and fashion in some of the larger cities of the East or of Europe. The number of the population who prepare their victuals over the camp fires, or in the rudest cabins, and who work, eat, and sleep in the open air, is by no means inconsiderable. Closely-built buildings, heated with stoves, are the exception out of the larger towns. Most of the habitations are so constructed as to admit of free ventilation, and are warmed by the primitive back-log upon the hearth, or the little fire place in one corner of the room, where the wood is burned on end after the Mexican manner. It is my opinion that no small degree of the undoubted benefits of residence in these mountainous regions is, in certain forms of disease, attributable to these causes. From what I have observed, it is by those who place themselves under such circumstances, more frequently than by those who endeavor to approximate as closely as possible to the personal surroundings of older communities, that improvement in health is enjoyed. As a general thing, the more thoroughly the person can approximate his occupation and manner of life to the state of existence known as 'roughing it,' the better the result.

"The principal distinguishing feature of Fort Garland and vicinity, in a sanitary point of view, is its great altitude. Little perceptible effect is observed upon the respiration of persons in good health, as a general thing, but some individuals do complain of a want of breath on slight exertion. The respiration is somewhat increased in frequency, and the action of the chest deeper than at ordinary altitudes. This is rendered necessary from the fact that a greater volume of air is required to furnish a given quantity of oxygen to the economy in this place, where the barometer indicates a pressure of only about 22.50 inches, than at ordinary levels.

"To this increased mechanical action or play of the lungs, and distention of the parenchymatous tissue, may be attributed part of the beneficial effects of high altitudes in certain diseases of these organs. The effect of this place (San Luis Park, Col., altitude 7,805) upon the circulation is quite as marked as upon the respiration. The pulse of fifteen persons, all in good health, was carefully noted. In every case

the person was in a state of quiet at the time of the examination, the subjects being either seated or in the recumbent posture. Three of the number were females. The average per minute of the fifteen was, in round numbers, ninety, lacking only the slightest fraction. In examining the pulse for diagnostic purposes, I had, prior to these observations, and almost unconsciously, dropped into the habit of allowing an increase of ten to fifteen in frequency over the usual rate per minute without attaching any significance thereto. A very noticeable feature in connection with the pulse is its rapid rise in frequency upon exertion. The pulse in four persons in perfect health was noted while at rest, and again after a brisk walk on level ground of a hundred yards, with an increase in frequency, respectively, of 28, 42, 35 and 23 per minute. This rapid action of the heart and excitability upon exertion is in accordance with the increased rapidity of the respiration, but it constitutes a very serious objection to this place as a residence for those laboring under cardiac disease, or any affection in which it forms a complication. I have not seen cases of this nature here; but from what I have observed in other localities of considerable altitude, I am satisfied of the truth of this remark. Altitude seems to have an effect upon those suffering from heart disease something similar to the exertion of ascending a stair or walking up hill. In any case in which this condition exists as complication, whatever may be the benefit otherwise, I am satisfied that the embarrassment caused to the heart will be a serious offset, if not an insuperable obstacle, to any real improvement. . . .

"Vesicular emphysema, and that form of chronic bronchitis associated with disease of the heart, I believe unsuited to a residence here, or in any locality possessing this altitude. The other forms of chronic bronchitis, chronic pneumonia, and phthisis, are the diseases par excellence for which I believe this region peculiarly well fitted.

"A case is under my observation at present at this post, of a man who left the Atlantic coast a little over one year ago, and came to Colorado for his health. Before leaving the East he had suffered three alarming hemorrhages from the lungs, and his case was considered grave in the extreme. Since coming to this region he has much improved, and has had no repetition of the hemorrhage. A permanent residence in this country will, in all probability, confer length of years upon a life which was considered doomed before he left his home in the East. Another case has come under my observation in contrast with this, where a man came to this region in the third stage of pulmonary tuberculosis ten months ago. He was not improved by coming here; but on the contrary, the increased labor imposed upon the portion of lung still remaining caused a constant uncomfortable feeling of want of breath. At an unexpected moment, after he had been in this country some months, violent pulmonary hemorrhage occurred, and the man died within ten minutes."

Of 2,124 cases of disease recorded at Forts Garland and Lyon, Colorado, during four years, 1870–1874, 5, or 1 in 422.8, were for consumption. Of these, 1,267 cases, and 4 for consumption occurred at Fort Garland, 7,805 feet elevation; and 857 cases, and 1 for consumption, occurred at Fort Lyon, 3,800 feet elevation. The most prevalent diseases at both places were catarrh and bronchitis, and diarrhœal diseases.

At the military posts of Kansas for the same period, 15,051 cases were recorded, of which 29, or one in 347.3 were for consumption.

In Nebraska, for the same period 9,777 cases, of which 14, or one in 698.3, were for consumption. Catarrh and bronchitis, and diarrhœal diseases, were alike the most prevalent diseases in the military posts of both these States.

Wyoming. Assistant Surgeon Charles Smart reports from Fort Bridger, altitude 7,010 feet.[1]

"The climate is temperate and salubrious the greater part of the year. The weather during the fall months is mild and delightful, excepting a few snowstorms of short duration. No severe weather occurs before the middle of December; after that time there are frequent storms and high winds. Cold weather continues late in the spring, and the grass does not begin to grow until in May. Although the post is in a valley, with streams all around and through it, the atmosphere is comparatively dry, the reading of the wet and dry bulb thermometers varying from ten to fifteen degrees. The prevailing winds are from the west, and on an average blow from that quarter twenty-eight days in a month.

"In investigating the amount and the character of the sickness at this station, the records of the past eight years, 1866–1873, have been examined. Although the port has been in existence since 1857, the records are complete only from the close of the war, when the volunteers were relieved by a regular garrison. During these years 2,335 cases were entered on the register, of which six died and forty-nine were discharged,[2] an annual average of 1,932 cases per thousand of mean strength, with a mortality of 1 in 392 cases. This is a healthier record than the average of the army during the same period. The discharges, as a whole, have a greater bearing on the physique of the recruits received than the diseases prevalent at the station; setting them aside, the other diseases show to the advantage of Fort Bridger. If we express the sickness and mortality of the army, each as a unity, Fort Bridger's sick-roll will be represented by .81, and its mortality by .25. Acute rheumatism, conjunctivitis, catarrh, quinsy, laryngitis, and phthisis are specially the diseases of the station. These would seem, with the exception of conjunctivitis, to be developed from climatic influences. The spread of the eye diseases was the result of low ceilings, overcrowding,

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[1] Op. cit., p. 316.
[2] Op. cit., p. 316.

and deficient means for effecting personal cleanliness. It continued prominent on the records for three years, and disappeared with repairs and improvements, which furnished increased air-space by heightening the ceiling of the barrack-rooms and abolishing double-tiered bunks. This point in the history of the post offers a good example of what sanitary science can accomplish. Non-professional men, in their superiority to such trifles, may smile at the doctor's insistance on air-space, ventilation, lavatories, and so on; but a disease completely expunged from the record by attention to these trifles proves the virtue there may be in them.

"Acute and chronic bronchitis, pneumonia, and pleurisy are rare diseases at this station, only three of pleurisy and two of pneumonia having occurred during the eight years. This is a favorable showing; nor is it detracted from by the fact that four of the six deaths are set down to lung affection. Two are reported as from congestion of the lungs; but intemperance and exposure are added, materially qualifying the part which climate enacted in the deaths. The third was from abscess of the lung (latent) in a soldier prematurely old, and broken down by long courses of dissipation. The fourth is from 'acute phthisis,' as a sequel to mountain fever. Peritonitis is responsible for the fifth (particulars not given), and penetrating chest wound for the sixth. . . .

"In a tabulated statement of sickness, giving the monthly ratios per thousand of mean strength, average of eight years, 1866-73, the lines foot up:

Average mean strength, .	153	Pleurisy, ...	2.48
Remittent fever, . .	48.03	Inflammation of lungs, .	1.76
Catarrh, ...	400.95	Phthisis, ...	10.76
Quinsy, ...	84.51	Acute inflammation, .	92.58
Laryngitis	5.29	Chronic rheumatism, .	18.61
Acute bronchitis, . .	13.05	Total climatic disease, .	680.44
Chronic bronchitis, . .	2.42		

"From the above it is seen that catarrh, numerically considered, is pre-eminently the disease of the station, four out of every ten men being affected annually. It is difficult to perceive why March should exceed the other months so remarkably in its production of this disease, unless it be attributed to the alternate freezing and thawing, caused by variations above and below the mean temperature of 28.51° Fahrenheit. April, May, and June follow on the list; the gradual rise in the temperature melts the snows of winter, necessitating precautions against damp feet from slush and mud, and furnishing more cases than the colder months. Another cause of the prominence of this disease during the months of rising temperature is the change which the warm mid-day hours call for in the soldier's clothing: the extra shirt is laid aside, and after sunset a slight chilliness ushers in the attack. July, August, September, and October have less of these cases, August notably so.

"Pure cold seems to have much to do with the production of tonsillitis; December and January, the two coldest months, giving by far the largest numbers, although February, which takes rank next as to cold, gives fewer cases than the warmer months that follow, perhaps because the variation and humidity are relatively less. In this disease also, June shows the effects of lessening the clothing. In August and September the disease is at its minimum. I believe that these catarrhs and quinsies could be much reduced by a system of ventilation. During four months of the year, the temperature falls below zero at night. The great object of the men in quarters in such weather is to keep warm. The fires are well attended to, and every chink which admits fresh air, and can be reached, is carefully stopped up. With the thermometer so low, there is seldom any wind to promote change in the atmosphere of the room, and it soon becomes loaded with exhalations and depressingly warm, leading the men to sick-call from exposure at the reveille; properly constructed ventilation, which would renew the air and prevent the rooms from becoming overheated, would relieve the sick-report of many a case which burdens it under existing arrangements."

These remarks are no less significant in regard to *family* quarters in the ordinary domicile in cold seasons and climates in the United States generally, than to soldier's quarters.

"Laryngitis appears in the colder months and early spring, and is unknown in the summer.

"Rheumatic fever is scattered over the months without reference to season, wind, humidity, temperature, or its fluctuations. . . .

"Summer is the season for the remittents, but they appear during all the other months, except September and October. I am not aware of any case of consumption which has originated in this neighborhood; but although the country has been settled as now for some fifteen years, and several large families have been brought up, the population is too scanty to give this point by itself much weight. The prevailing impression among the citizens is that the climate, though severe in the winter, is very beneficial to such cases of consumption as are able to stand it. Such ideas among the people are usually the reflection of professional opinion, and I state the above to indicate what has probably been that of my predecessors at the post.

"Twelve entries of consumption appear on the registers: of these, one died, as recorded above; eight were discharged, one returned to duty, and two are presumed to have returned, although mutilation of part of the records prevent certainty; at all events, they are not borne on the monthly reports as discharged or dead. Of the eight discharged, one only is stated to have originated prior to entry into the service; the other seven are reported as having been developed in the line of duty—that is, the men, whether affected with incipient phthisis or not before their arrival in this climate, were able to perform their duty while at the post,

and broke down under the progress of the disease while exposed to the climatic influences of the station. To the twelve entries I have added in the table a thirteenth, appearing in May, 1871, as a discharge for "debility on account of catarrh." This gives 10.76 per thousand of mean strength of cases of consumption developed at Fort Bridger annually, to such extent as to cause withdrawal from duty for medical treatment, and 8.3 per thousand dead and discharged by reason of this disease, while only 3.5 per thousand required medical treatment in the army as a whole.

"These figures do not support the popular opinion with regard to Fort Bridger. Even allowing that three of the cases (2.43 per thousand) were so improved by the climate as ultimately to recover, the same climate is responsible for the attack which brought them to the hospital from the performance of duty, and it is also responsible for the death and discharge of the remaining ten (8.33 per thousand), while the temporary and permanent disablement from duty through such cases by the average climates of the United States army stations is but 3.5 per thousand. The rarity of acute bronchial and pulmonary inflammations is in striking contrast to the marked progress which is indicated in the development of the phthisical cases, and lends to the figures of the latter greater value than they would possess if presented alone.

"The immunity from consumption possessed, as a rule, by the inhabitants of elevated lands has led to belief in the curative influence of a residence in such climates, provided the disease be in an incipient stage, or, as the people here say with more unwitting caution, provided the patient is able to stand it. The cases above noted were in the incipient stage, perhaps free from everything but the hereditary predisposition, for it cannot be assumed that these soldiers were doing duty while in the advanced stages, yet they were not able to stand it. Overheating and impure air" (in the garrison), "already spoken of, no doubt had an influence on the development of the cases; but these facts do not detract from the value of the figures in the question or causation of influence of climate. Bad ventilation and overheating affect more garrisons than that of Fort Bridger, and have their effect expressed in the 3.5 per thousand, while the excess of overheating, with its results, at this post, is reflected back on climate by the cold which originates it."

Of 8,730 cases of disease of all kinds recorded at the military posts of Wyoming during the period of four years, 1870–74, 41, or one in 213, were for phthisis. In Montana, for the same period there were recorded at the military posts 2,742 cases, of which 11, or one in 249.3, were for consumption. In the military posts of both these States, the most prevalent diseases were catarrh and bronchitis, rheumatism and diarrhœal diseases.

In Idaho, at an altitude of 2,880 feet, latitude, 43° 37′ north; longitude, 39° west; the climate as observed by Assistant Surgeon Geo. P. Ja-

quett, U. S. Army,[1] is generally very healthy. There are two seasons, the wet and the dry, but annual rain-fall is light. Only a few cases of the common varieties of disease occurred at the post: 201 during four years out of 169 mean strength of enlisted men, and no case of consumption.

At Fort Hall, located in Lincoln Valley, on the Snake River, latitude 43° 7′ north; longitude, 35° 12′ west; altitude, 4,700 feet above the level of the sea, Assistant Surgeon J. T. Pindell, U. S. Army,[2] describes the climate as being generally pleasant, though subject to wide ranges in temperature. Lincoln Valley lies among the foot-hills bordering the Snake River basin on the East, and measures in its course from north to south about five miles in length, and in the immediate vicinity of the military post, one-half mile in width. It is well sheltered from the cold winds by the surrounding hills.

Of 148 cases of disease recorded at the post in four years, one was for consumption. Rheumatism was the most prevalent disease; there was no disease of special significance with regard to climate.

In latitude 46° 32′ north; longitude 40′ west; the site of Fort Lapwai, near Lewiston, a town of about five hundred inhabitants, twenty-five miles west of the Blue Mountains, "a wind, called by the natives 'chinook,' is prevalent at all times of the year. It comes suddenly with great violence, and is always attended with a very great rise in the temperature. In winter, one of these winds has been known to commence blowing in the evening, at a time when there have been three or four inches of snow on the ground, and by morning not a trace of snow could be seen. In the summer, the heat attending them is like that from a furnace, and vegetation withers before the hot blast."[3] The most prevalent diseases, according to the records of the post, are rheumatism, catarrh, and bronchitis. Of 469 cases of all kinds recorded in four years, there was one only from consumption.

"The climate of Utah[4] is quite similar to that of Northwestern Texas and New Mexico, and is agreeable most of the year round, excepting for a month or so in winter. The temperature in winter seldom drops to zero, and only two observations below that point have been taken since the post was established. The humidity reaches its maximum in the spring months, when the atmosphere is almost saturated. This arises from the winds at this season passing over Great Salt Lake from the

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[1] Fort Boisé. Op. cit., p. 457.

[2] Op. cit., p. 505.

[3] Report of Assistant Surgeons C. R. Greenleaf and George C. Douglass, U. S. Army. Op. cit., p. 57.

[4] Reported by Surgeon E. P. Vollum from Camp Douglas, situated on a plateau at the base of the Wahsatch Mountains, two and a half miles east of the business portion of Salt Lake City, at an altitude of 730 feet above it. The altitude of the sun-dial is 4,904. Latitude, 40° 46′ 2″ north; longitude, 35° west. Op. cit., p. 332.

northward, bringing the watery vapors, not only from that great body of water, but also from the regions beyond, supplied by the southwesterly currents that are seen to pass over at a great altitude, most of the winter long. Great Salt Lake, with a shore-line, exclusive of offsets, of 291 miles, is vast enough to furnish a horizon, in places, like the ocean itself; and being at an altitude of 4,200 feet, some travellers have imagined that on its shore was to be found the most peculiar and unique climate on the face of the globe, combining, as it does, the light pure air of the neighboring snow-capped mountains with that of the briny lake itself; and it is fancied by many that at certain points one may inhale an atmosphere salty and marine, like that found on the shores of the Atlantic, happily combined with a cool fresh mountain air, like the breath of the Alps themselves. Owing to the absence of marine vegetation about the shores, however, there are none of the pleasant odors to be found, as on the sea-shore. For several years past, the snow has seldom fallen to a greater depth than a foot, and it soon melts away, while up to 1860 a fall of three feet was not uncommon, with sleighing for a month or so at a time. No tide-gauge observations have ever been made to determine the change in the level of Great Salt Lake, but the inhabitants about the shore estimate that it has risen about one foot a year during the past ten years, which change of level has been caused by the steady increase of the rainfall of the country, as well as the swelling of the streams flowing into the lake, that drain about one-half of the Territory, most of them flowing from the mining districts, where the tunnelling, excavations, blasting, etc., tap the mountains in thousands of places where water never flowed before, for every mine becomes a source of water, sometimes in large amount. The increase in the atmospheric humidity is no doubt in large part caused by the multiplication, of late years, of the irrigating canals, which expose an immense area of water for evaporation. This is evident in many places by the increased fertility of the lands and increased greenness of the landscape, and if it continues the necessities of agriculture will soon be met, which in fact is the case at present, were the annual amount, about twenty inches, well distributed throughout the year.

"The spring begins about the middle of March, and it is a splendid season. The atmosphere becomes as clear as a diamond, distances vanish as by enchantment, and Great Salt Lake, twenty miles off, appearing like a broad band of indigo, studded with mountain-islands set on its surface like glittering jewels, seems but an hour's ride away. The city, which is a vast orchard dotted with houses half buried in the foliage, becomes a mass of color, variegated by clumps of the bright blossoms of the peach, pear, apple, plum, and apricot, mingled with the tender colors of the willow, cotton-wood, and mulberry. The bright green surface of the valley follows the snow-line as it rises up the mountain sides, leaving a strip of russet color between.

"The summer may be said to be hot, dry, and dusty. The mercury seldom rises above 95°, though once, in August, 1871, it reached 105°, and the range is about 30° during the hottest weather, which is necessary to insure the cool breezes found so refreshing at night after the heat of the day. At this season, the atmosphere is yellow and brassy, and the flying dust clouds, from the parched desert surfaces hundreds of miles away, pass over the highest mountains and thicken the air, and while the valley may be regarded as an oasis, yet at this season it furnishes its quota of dust, and the teamsters and road people coming in from a journey suffer from ophthalmia, irritative catarrh, and cough, caused by impalpable particles of alkaline matter that fill the air.

"The autumn, on account of the high winds, is the most unpleasant season of the year, and the dust-storms often obscure the noonday sun, and fill every nook and corner with dirt, from which there is no escape; but as the season advances, the aërial movements dwindle down to the little spiral dust-whirls that may be seen in many parts of the valley, at the same time furnishing a curious spectacle. In October, the atmosphere, crisp and bracing, clears up again as in spring, and the landscape softens with the rich browns, russets, and scarlets of the dying vegetation, which reaches high up, and mingles with the high rocks at the tops of the mountains, soon to be overlaid, however, in these elevated situations, by the first snows of the season.

"The new-comer for a short time feels a difficulty of breathing, arising from the altitude, and the same trouble is often seen with horses, and occasionally travellers speak of feeling giddy and unseated from the same cause. About once in ten years an epidemic of "mountain fever" appears to a considerable extent throughout the Rocky Mountain regions, including Utah. Its last appearance was in the fall and winter of 1871–72. It is a malarial fever commencing as an intermittent, passing on into a remittent, then into a typhoid condition. It may often be cut short by prompt large doses of quinine; but after the typhoid symptoms set in, it should be regarded as a typhoid fever, and so treated. The mortality is often high, but reduced in proportion to the attention a patient receives in the early stages.

"*Special report on some of the diseases of Utah.*—Regarding the principal diseases of Salt Lake valley, and the influence of the climate and the altitude on lung troubles especially, I will summarize my views briefly, as follows: The adult population are as robust as any within the borders of the United States, and there is a fair number of cases of extreme old age. The weight of sickness falls upon the children, who furnish not less than two-thirds of all the deaths, most of which occur under five years of age. Looking over the registers of the undertakers at Salt Lake City, I find the causes of death classified under these headings:

"'Males, females, adults, children, country, transient, resident, bowels, lungs, brain, fever, inflammations, child-bed, still-born, old age,

polygamy, monogamy, killed accidentally, dropsy, debility, and sundries;' the last heading meaning unclassified. The following abstract from the undertakers' books shows the percentage of deaths of the diseases mentioned to the whole number of deaths for the years quoted up to September, 1874:

Diseases of the	1870.	1871.	1872.	1873.	1874.
Bowels	20.10	23.36	26.44	21.15	10.87
Lungs	23.34	23.56	19.55	20.00	26.23
Brain	12.10	5.24	5.28	6.87	8.22
Fever	....	11.13	10.24	13.20	12.46

"The figures of the registers show that the male deaths exceed the female in number about 50 per cent. I cannot get the relative proportion. The polygamous children are as healthy as the monogamous, and the proportion of deaths is about the same; the difference is rather in favor of the polygamous children, who are generally, in the city especially, situated more comfortably as to residence, food, air, and clothing, their parents being better off than those in monogamy. It is perhaps too early to express any mature opinions as to the influence of polygamy, as contrasted with monogamy, on the health or constitutional or mental character of the Anglo-Saxon race as seen in Utah; but as far as the experience has gone, which is long enough to furnish quite a population, ranging from twenty-five years downward, no difference can be detected in favor of one or the other. . . .

"Referring to the undertakers' headings mentioned above, 'bowels' covers chiefly the common bowel complaints of children that are caused principally by exposure to changes of temperature, dabbling in cold water, poor, coarse and inappropriate food while sick, lime and alkaline drinking-water, and neglect of medical attendance and proper nursing. Under the heading of 'lungs' are grouped phthisis, pneumonia, pleurisy, pleuro-pneumonia, and bronchitis.

"Regarding the influence of the altitude and climate of Utah on phthisis, it may be set down as favorable. My experience here with that disease during the past four years has been very small, and my testimony on the subject may, therefore, be regarded as in favor of the climate. At Camp Douglas, my observations have been confined to a few incipient cases among the troops who came from a distance with it and were discharged, to an officer's wife who inherited it from her father, and who took cold at a ball when far advanced with it, and passed rapidly on to the last stages, returned home and died; and to the case of my assistant, Dr. John E. Spencer, which I will mention. He inherited the disease from his father, developed it by overzeal in hospital and

dissecting-room ; and he sought employment in the army, with a view of getting stationed somewhere in the interior, elevated region of country. Circumstances brought him to this place. When he reported, he was pale, thin, and feeble, having some time before had serious hæmoptysis; his pulse was small and rapid, and his respiration hurried and difficult, and a constant harassing cough that brought up considerable expectoration. A walk of a thousand yards would require him to lie down to recover his wasted strength. His lungs were both consolidated at the top; there was a cavity of some size in the upper lobe of the eft lung that gave out a rattling, sibilant sound that could be heard a short distance from him. The bracing weather of the fall coming on soon after his arrival, he commenced to practise a little horseback riding, and before the winter was well advanced he could ride to Salt Lake City, three miles off, and back, with little fatigue, spending the remainder of the day in comparative quiet. By the following spring, though the winter was open, wet, and changeable, the cavity in his lung was closed up, and gave no sound to the ear on the chest, and the tubular râles had mostly ceased, and his face took on the color of health; he increased some twenty pounds in weight, and expressed himself as being as well as he had ever been, his cough having subsided to a minimum condition of a hack, at long intervals, brought on by a bit of food, flying dust, or laughter. During this time, he adopted no treatment whatever, and only occasionally took a glass of whiskey as a tonic. Having occasion to go to Omaha a year and a half afterward, he contracted measles while there, and returned with his cough re-established and expectorating freely. The cavity in the left lung re-opened, and his general condition was nearly as bad as it was when he first reported. Exposure at his door, when half dressed one night to respond to a patient's call, gave him a chill that was followed the next day by nearly a fatal hæmoptysis. Fearing the influence of the coming winter, he took up his residence at Santa Barbara, California, and there regained the good condition he enjoyed at this place; but he allowed his energy to run away with him, he accepted two offices under the corporation, and after an occasion of overwork and zeal connected with his duties, he had a hemorrhage and died.

"During my stay here, I have travelled over the length and breadth of the Territory, and have made quite an intimate acquaintance with the people of all classes and degrees, and have yet to learn of a case of phthisis that originated in the country, and was unconnected with hereditary transmission. Cases of this kind are sometimes seen in children, the offspring of strumous and consumptive parents. As I have formerly reported, it is the opinion of the local physicians, as well as of the people generally, that if a case comes here in the incipient stage, and is well circumstanced for comforts, it will get well spontaneously from the beneficial effects of the altitude and the inland dry char-

acter of the atmosphere. It is the boast of the people that this is not a consumptive country, which is my opinion decidedly. On the other hand, it is believed that if a patient comes here in the latter stages of the disease, the atmosphere is too rare to give proper support, and that the case will be hastened to a termination more speedily than on the sea-coast."

"Altitude is doubtless an important element among the means of relief and cure of phthisis, but it should not be too great. The highest places among the Rocky Mountains have seemed to have a fatal influence on some cases that have been brought indirectly to my attention. The best level has yet to be determined, as the experience of travellers over the Union Pacific Railroad proves. Patients of this class frequently pass over the road eastward and westward, and they often sink on the way, in consequence of the strain put upon their breathing by the rare atmosphere of the highest places where they suffer intensely from oppression and difficult breathing. The porters on the sleeping cars of the road have become accustomed to such cases, and their common remark is, if such and such a case passes safely over the divide or highest point, at Sherman, which is 8,242 feet above the level of the sea, they will reach the end of their journey, a number of such patients having died at that point.

"While at Fort Crook, California, in 1849, I saw quite a number of persons in the neighboring country who professed to have been cured of phthisis by crossing the plains on horseback; and from a knowledge of their habits and the condition of that journey, I then conceived that the best treatment known for consumption was a year of steady, daily horseback-riding in a mountainous country, and a diet of corn-bread and bacon with a moderate quantity of whiskey; and I may say that my experience has taught me nothing better since.

"The beneficial influence of this climate on asthma is decided, and deserves a prominent mention. It is also the boast of the people, as well as the physicians, that asthma cannot exist here excepting under a relieved and modified condition, which I think is the case. . . .

"Bronchitis appears in a mild form during the wet and thawing periods of spring and fall; but it always yields to treatment, and I have heard of no deaths from it.

"Pneumonia may be regarded as a disease most liable to be produced by the conditions of the climate, and it doubtless makes up the bulk of cases reported as lung disease on the death register of the city undertakers."

Two hundred and fifty miles south of Salt Lake City[1] "the atmosphere is extremely dry. The amount of rainfall is very small; the

[1] From Post Beaver; latitude, 38° 16′ north; longitude, 34° 50′ 30″ west; 6,200 feet elevation, Assistant Surgeon F. W. Elbrey. Op. cit., p. 222.

number of cloudy days in the year very few. The prevailing winds—and the winds are frequent and of great force, driving before them clouds of dust—blow from the southwest and northwest. Owing to the rapid radiation of the earth's heat, the variation between the temperature of the day and that of the night is always great, often amounting to 40° and rarely less than 20°. Not often does the thermometer rise higher than 90° in summer, or sink to zero in winter. Cool nights are the rule in summer, and cold nights even to freezing begin in September and continue till June. Indeed, no month in the year can be counted upon as being surely free from frosts. The climate is healthful, owing to the diurnal variations in the temperature; catarrhal affections are of comparatively frequent occurrence. Phthisis, when fully established, is not at all benefited by a residence here; but phthisis does not frequently originate here."

Of 432 cases of disease recorded at this post during four years' observation, 1870–1874, five were for consumption.

In Dakota, the climate is cold and dry, and high winds common. Catarrh and bronchitis are among the most common diseases.

In the valley of the Red River of the North, about 1,700 feet above the level of the sea, the climate is less severe than here, "phthisis pulmonalis, pneumonia, and most other lung diseases are rare. The only diseases which seem of endemic origin, are a peculiar pharyngitis and tonsillitis, and asthma, which are usually made worse when already existing, and sometimes brought on when not before known to exist. Both of these diseases may have their origin in the fungus of the wild grasses of the prairie surrounding the post (Fort Abercrombie), through this view has not been experimentally established." [1]

Of 6,014 cases of disease recorded in the ten army posts during the four years, 1870–74, 26, or 1 in 231, were for consumption. The most prevalent diseases were catarrh and bronchitis, diarrhœa and dysentery.

In New Mexico, the *Ojo Caliente* Springs, Taos County, which appear to have been known from the first settlement of that country by the Spaniards, have recently been made accessible by Denver and Rió Grande Railroad. They are situated at an altitude of 6,000 feet above the level of the sea, twelve miles distant by stage from Baranca, a station on the railway. The flow of the water is 1,000 gallons a minute, and the temperature 122° F. One pint contains (Prof. O. C. Marsh):

Solids.	Grains.
Carbonate of soda,	11.440
Carbonate of magnesia,	0.158
Carbonate of iron,	0.737
Carbonate of lime,	0.303

[1] Assistant Surgeon W. H. Gardner. Report from Fort Abercrombie. Op. cit., p. 390.

	Grains.
Carbonate of lithia, ...	0.015
Chloride of sodium, ...	0.772
Sulphate of potassa, ...	0.376
Sulphate of soda, ...	0.991
Silica, ...	0.153
Total, ...	16.945

The *Agua Caliente* Springs, in Mesilla County, are also probably destined to become, ere many years, a deservedly popular resort. Dr. T. Antisell, geologist of the U. S. Exploring Expedition, gives the following description:

"Between the Mimbres and Ojo de la Vacca, and close to trail leading from the former to the copper mines, is that remarkable spring known as the 'Agua Caliente.' It lies about five miles from the river; where the springs issue is a mound or bank of tufaceous deposit, formed by the overflow of the spring at some former time, previous to the side-channels being formed. This mound is twenty feet above the valley level, and two and one-half feet above the level of the water in the spring, showing that the spring, by the deposit of carbonate of lime from its waters, has formed a basin-wall for itself, and allowed its level to be raised above the surrounding valley. This calcareous basin is twenty-five feet across and does not show bottom, except around the edges, which are rocky; a twelve-foot pole thrust into the middle did not find bottom. The temperature of the spring was 130° Fahr. at the surface. From one point below bubbles of gas arose in great abundance (carbonic acid). The water is agreeable to the taste." [1]

In Colorado, the *Middle Park Hot Springs*, situated in Grand County, eight thousand feet above the level of the sea, in the midst of magnificent scenery, are rapidly coming into favor. They are accessible by stage and horseback, about sixty miles from Central City, on the Colorado Central Railroad; or by one hundred miles stage and horseback from Golden City, on the same railroad. "The favorite route," as given by Walton,[2] "is by the way of Berthoud Pass. Having arrived at Georgetown, the tourists procure saddle and pack horses, and guides. The first day's journey will be over the summit of the range, eleven thousand feet above the level of the sea, and through a dense forest of timber for fourteen miles beyond, to the head of the park. Here camp is usually made. The next day's ride is down an open valley or arm of the park, following for some miles the course of Fraser's River. The route by South Boulder Pass is tedious and difficult, the road passing over the extreme summit of the range, more than 12,000 feet above the sea, where snow-storms are not unusual in July and August. The

[1] T. Antisell, M.D. "Government Exploration for Pacific Railroad," vol. vii., p. 156.

[2] Op. cit , p. 306.

James Peak route is one of the most interesting, the road winding around the mountain, one of the highest points in the range, and the the ascent easily made. All the roads, however, after crossing the mountains, meet together in the valley of the Fraser River. Thence the road is a pleasant carriage-drive along the meadow-like valleys, with timbered ridges or table-lands to the right and left. The grass is of luxuriant growth and great variety. Clover of several kinds, and the blue flowering flax, are seen everywhere. All through late spring and early summer, the prairies are bright with flowers, and the air laden with their fragrance. Delightful camping places are seen all along the route, and days or weeks can be whiled away in Arcadian simplicity and enjoyment.

"Arrived at the Springs, there are several houses, a little trading establishment, and a primitive blacksmith-shop. The springs, many in number, are grouped together on an embankment, three hundred feet from Grand River, and about thirty feet above it. The stream formed by the united overflow of the springs is from three to five inches deep, and four to six feet wide. The flow is probably much greater than that recorded. The sources vary in temperature from 111° to 116° Fahr. Curiously enough, on the opposite side of the river is a *cold sulphur spring*."

One pint contains.	No. 3. 97½° F. E. J. Mallet.	No. 5. 115° F. E. J. Mallet.
SOLIDS.	Grains.	Grains.
Carbonate of soda	3.687	4.921
Carbonate of magnesia	....	0.241
Carbonate of lime	....	0.460
Carbonate of sodium	1.661	1.745
Sulphate of potassa	0.129	0.119
Sulphate of soda	2.191	1.231
Sulphate of magnesia	0.656	....
Iron and ammonia	traces	traces
Lithia	traces	....
Silicic acid	0.077	0.164
Total	8.401	8.881
GASES.	Cubic inches.	Cubic inches.
Carbonic acid	2.22	2.50

Manitou Springs, Manitou, El Paso County, five miles west by stage from Colorado Springs station, on Denver and Rio Grande Railroad, 6,529 feet above the level of the sea, and within view of Pike's Peak. No analysis of this water accessible; but from an analysis of the salts,

obtained by boiling down an unknown quantity, T. M. Drown, of Philadelphia, gives the following percentage:

	Grains.
Bicarbonate of soda,	24.01
Bicarbonate of magnesia,	8.89
Bicarbonate of lime,	15.62
Chloride of potassium,	10.01
Chloride of sodium,	36.69
Sulphate of soda,	4.78
	100.00

Pagosa Springs, in Conejos County, from Del Norte, a station on Del Norte Branch of Denver and Rio Grande Railroad. *Hot purgative waters,* said to resemble the famous Carlsbad of Bohemia. One pint contains (140° Fahr.):

Solids.	Grains.
Carbonate of soda,	0.342
Carbonate of lime,	0.353
Carbonate of lithia,	4,300
Carbonate of sodium,	0.051
Chloride of sodium,	2.132
Sulphate of potassa,	0.519
Sulphate of soda,	16.146
Silica,	0.415
Organic matter,	trace.
Total,	24.258

Rocky Mountains Springs, Boulder County, twelve miles from Jamestown, a station on railroad from Denver to Boulder City. *Calcic-aperient and chalybeate.* One pint contains (C. T. Jackson):

Solids.	Grains.
Carbonate of soda,	0.474
Carbonate of magnesia,	0.049
Carbonate of lime,	5.414
Carbonate of iron,	0.362
Chloride of sodium,	0.620
Sulphate of soda,	13.075
Iodide and bromide of sodium,	0.162
Silicate of soda,	0.500
Total,	20.656

Carbonic acid gas, amount undetermined.

Idaho Hot Springs, Clear Creek County, Col., Colorado Division of Union Pacific Railroad from Denver, thirty-eight miles from Denver. One pint contains (85° to 115° Fahr. J. G. Dohle):

Solids.	Grains.
Carbonate of soda,	3.85
Carbonate of magnesia,	0.36
Carbonate of iron,	0.52
Carbonate of lime,	1.19
Chloride of sodium,	0.52
Chloride of magnesium,	trace.
Chloride of calcium,	trace.
Sulphate of soda,	3.67
Sulphate of magnesia,	2.34
Sulphate of lime,	0.43
Silicate of soda,	0.51
Total,	13.39

Canon City Springs, Canon City, Fremont County. Station on Pueblo Branch of Denver and Rio Grande Railroad, one hundred and sixty-one miles from Denver. *Mild alkaline,* and *warm:*

One pint contains.	Iron Duke. Prof. Leon.	Little Ute. Prof. Leon.	Hot Springs. 102° F. Prof. Leon.
Solids.	Grains.	Grains.	Grains.
Carbonate of soda	9.598	9.548	9.148
Carbonate of magnesia	1.824	1.749	1.599
Carbonate of iron	trace.	trace.	trace.
Carbonate of lime	4.124	2.812	4.086
Carbonate of lithia	trace.	trace.	trace.
Chloride of sodium	10.373	14.747	2,264
Sulphate of soda	1.524	1.513	9.910
Total	27.443	30.369	27.007

Chalk Creek Hot Springs, Chaffee County, P. O. Nathrop, Col. Temperature, 130° F. One pint contains (Prof. G. E. Patrick):

Solids.	Grains.
Carbonate of potassa,	0.016
Carbonate of magnesia,	0.078
Carbonate of lime,	0.244
Chloride of potassium,	0.079
Sulphate of soda,	0.771
Silicate of soda,	0.324
Silica,	0.254
Lithia,	trace.
Organic matter,	trace.
Total,	1.766

Carlisle Springs and *Parnassus Springs,* South Pueblo, Pueblo County, are good *alkaline* waters with some chalybeate properties.

Porter Springs, near Denver, are *sulphurous-chalybeate.* One pint contains (Prof. E. J. Mallett, Jr.):

SOLIDS.	Grains.
Carbonate of soda,	0.726
Carbonate of magnesia,	0.124
Carbonate of lime,	1.285
Chloride of sodium,	0.666
Chloride of magnesium,	0.142
Sulphate of potassa	0.037
Sulphate of soda,	3.442
Sulphate of sodium,	0.238
Silicate of soda,	0.112
Oxide of iron	0.187
Ammonia,	trace
Total,	6.959

Carbonic acid gas, and sulphuretted hydrogen in undetermined quantities.

South Park Springs, Park County, on the South Platte River, in the southern portion of the park, eight to ten thousand feet above the level of the sea, surrounded by magnificent scenery, are *alkaline.*

The American Geysers, in Wyoming, though with medical properties as yet undefined, are among the grandest springs in the world. As described by Gen'l H. D. Washburn, in *Scribner's Monthly,* in 1871:

"Our search for new wonders leading us across the Fire Hall River, we ascended a gentle incrusted slope, and came suddenly upon a large oval aperture with scalloped edges, the diameters of which were eighteen and twenty-five feet, the sides corrugated and covered with a grayish-white siliceous deposit, which was distinctly visible at the depth of one hundred feet below the surface. No water could be discovered, but we could distinctly hear it gurgling and boiling at a great distance below. Suddenly it began to rise, boiling and spluttering and sending out huge masses of steam, causing a general stampede of our company, driving us some distance from our point of observation. When within about forty feet of the surface, it became stationary, and we returned to look down upon it. It was foaming and surging at a terrible rate, occasionally emitting small jets of hot water nearly to the mouth of the orifice. All at once it seemed seized with a fearful spasm, and rose with incredible rapidity, hardly affording us time to flee to a safe distance, when it burst from the orifice with terrific momentum, rising in a column the full size of this immense aperture to the height of sixty feet; and through and out of the apex of this vast aqueous mass five or six lesser jets, or round columns of water, varying in size from six to fifteen inches in diameter, were projected to the marvellous height of two hundred and fifty feet. These lesser jets, so much higher than the main column, and shooting through it, doubtless proceed from auxiliary pipes leading into the prin-

cipal orifice near the bottom, where the explosive force is greater. If the theory, that water by constant boiling becomes explosive when freed from air be true, this theory rationally accounts for all irregularities in the eruption of the geysers.

"This grand eruption continued for twenty minutes, and was the most magnificent sight we ever witnessed. We were standing on the side of the geyser nearest the sun, the gleams of which filled the column of sparkling water and spray with myriads of rainbows, whose arches were constantly changing, dipping, and fluttering hither and thither, and disappearing only to be succeeded by others, again and again, amid the aqueous column, while the minute globules into which the spent jets were diffused when falling sparkled like a shower of diamonds, and around every shadow which the denser clouds of vapor, interrupting the sun's rays cast upon the column, could be seen a luminous circle radiant with all the colors of the prism, and resembling the halo of glory represented in paintings encircling the head of the divinity. All that we had previously seen seemed tame in comparison with the perfect grandeur and beauty of this display. Two of these wonderful eruptions occurred during the twenty-two hours we remained in the valley. This geyser we named the 'giantess.'

"A hundred yards distant from the 'giantess' was a siliceous cone, very symmetrical but slightly corrugated upon its exterior surface, three feet in height and five feet in diameter at its base, and having an oval orifice twenty-four by thirty-six feet and one-half inches in diameter, with scalloped edges. Not one of our company supposed it was a geyser; and among so many wonders it had almost escaped notice. While we were at breakfast upon the morning of our departure, a column of water, entirely filling the crater, shot from it, which, by actual triangular measurement, we found to be two hundred and nineteen feet in height. The stream did not deflect more than four or five degrees from a vertical line, and the eruption lasted eighteen minutes. We named it the 'beehive.'

Five other geysers were observed by the exploring party, which were variously named according to the degree of activity, the shape of the column of water, or the form of the siliceous deposit about the orifice. . . . The 'Fan' . . . The 'Grotto' . . . The 'Castle' . . . The 'Giant.' . . .

"The party did not analyze the waters. The sinter was both carboniferous and siliceous, the latter characteristic predominating; and we may with confidence conclude that the waters contains considerable silica in solution."

The springs observed in this region, which resembled boiling mud, deposited a sediment of various colors—some white, some delicate lavender, and others of a brilliant pink. An analysis of specimens of this sediment, by Prof. Augustus Staitz, gave the following results:

Solids.	White Sediment. per cent.	Lavender Sed. per cent.	Pink Sediment. per cent.
Silica	42.2	28.2	32.6
Magnesia	33.4	......	......
Lime	18.7	4.2	8.3
Alkalies	6.6	......	......
Alumina	......	58.6	52.4
Boracic acid	......	3.2	......
Oxide of iron	......	0.6	......
Soda and potassa	......	......	4.2
Water and loss	......	5.2	2.5
Total	100.0	100.0	100.0

In Nevada, *hot springs* have been described near Pueblo, in Humbolt County; and '*Volcano*' Springs in Lander County; but the surroundings have not yet been improved, nor the water analyzed.

In Montana, *white sulphur springs,* sixty miles by stage from Livingston, a station on the Northern Pacific Railroad, in a broad valley, surrounded by mountains, whose peaks are covered with perpetual snow, are said to exist, but no analysis of the water has been published, and improvements are yet in embryo.

In Utah, near Salt Lake City, *Salt Lake Hot* (sulphur) *Springs* are a popular resort for invalids from thereabouts for skin diseases and rheumatism. Temperature 110° to 128° F.; no analysis available.

CHAPTER XVIII.

CLIMATOLOGICAL TOPOGRAPHY AND MINERAL SPRINGS OF THE PACIFIC SLOPE.

THE mountain slope to the Pacific is, for the most part, very abrupt and irregular. It begins in latitude 62° north, with the descending grade of the Alaska Mountains southerly, and westerly into Alaska peninsula, 350 miles long and 25 miles in average breadth. And from the base of Alaska peninsula the slope continues an irregular parallel with the coast all the way from Alaska to Southern California. From the interior westward there is a continuous and quite uniform range—the Sierra Nevada of California, and the Cascade Mountains of Oregon. North of 50° latitude all these are merged into and consist of off-shoots from the Rocky Mountains. The whole range is sharp, with snowy, humid summits clothed with forests for the most part, and very rarely taking on the plateau form, except to a slight extent in the south of Oregon and the north of California. But at the southern extremity of the Sierra Nevada, latitude 34½°, the range declines so much from about that point to its termination in the peninsula of Lower California as to lose its climatic influence.

The climate of this extensive coast slope is exceedingly varied by reason of the broken nature of the surface, but greatly modified throughout by proximity to the ocean, and considerably warmer and more equable than in corresponding latitudes in the interior.

Of the surface and climate of Alaska, as observed in the vicinity of Sitka, Assistant Surgeon John Brooke, U. S. Army,[1] gives the following description:

"The town of Sitka, including the military post of the same name, is located on the western side of Baranoff Island, in latitude 57° 3′ north; longitude 58° 36 west. It is built upon the shore of Sitka Bay, about ten miles from the ocean, and upon a point of the island where the Bay divides into two arms, one of which runs about ten miles into the island, and terminates in Silver Bay, while the other passes round the northern end of the island to join the inland waters. . . .

"The physical appearance of the country around Sitka has been likened to the first picture in the common school atlas of the comparative height of

[1] Op. cit., p. 482.

mountains. A chain of mountain peaks of various heights encompasses the place on every side, except that toward the open sea, while the narrow strip of level country which lies between the town and the mountain base is so covered with moss and rotten timber that its surface resembles water-soaked sponges. Several small glaciers can be seen on the mountain sides during the middle of summer; in winter they are entirely covered with snow. Some ten or fifteen miles westward from the town is Mount Edgecomb, an extinct volcano, with the furrowed tufa near the top and the crater still plainly visible. It forms an important landmark for mariners entering the bay.

The tops of the mountains, which almost encompass the place, are more or less covered with snow and ice during the entire year, and consequently act as condensers to the moisture contained in the warmer air, which comes in from the ocean. Rain is, therefore, an almost daily feature of the place. During the winter, snow sometimes takes the place of rain, lying last winter to the depth of over three feet at one time. During the year 1873, the rain-fall was 74.64 inches. In one month of this year (October, 1874), it amounted to 17.98 inches. The cold is never very intense, the thermometer seldom, if ever, getting as low as zero; while, on the other hand, it rarely reaches 70° in the warmest summer weather, and fires are lighted almost every day in the year. During the shortest days there are but six hours of sunlight; and as the sun only attains an elevation of about 10°, it follows that on cloudy days, which is the rule, it is dark and gloomy at mid-day, while during the months of June and July it never grows entirely dark, the nights being rather a prolonged twilight.

"It might naturally be supposed that in such a climate acute rheumatism and acute pulmonary inflammation would be very common, but such is not the case. During a tour of nearly fifteen months, I have seen but one case of acute rheumatism, and not a single case of uncomplicated pneumonia or pleuritis. Cases of subacute rheumatism, however, and pains and aches of a few days' duration are quite frequent. Pulmonary phthisis is not uncommon, and forms a large percentage of the cases of disease even among the native Indians.

"Cases of sickness not infrequently occur in which there is a general adynamic condition of the system without definable disease, a condition which is doubtless due to the depressing influences of almost continuous wet, and cool and cloudy weather; a monotonous diet, in which fresh fruits and vegetables play an insignificant part; the almost entire absence of out-door amusements, and the want of opportunities for sufficient exercise in the open air."

Of 712 cases of disease recorded at the post during four years, 1870–1874, two were for consumption. The most prevalent disease was rheumatism, of which there were 130 cases. There were but four deaths, two

of which are classed under the head of "other local diseases," and the other two, one drowned, and the other suicide.

The climate of Washington Territory, at the altitude of 2,800 feet above the sea, latitude 48° 41′ north; longitude 40° 52′ west; is described by Assistant Surgeons E. G. Chase and W. D. Baker, U. S. Army,[1] as being cold in the extreme; the atmosphere dry, crisp, and bracing. "Malarial diseases entirely unknown in the country. Not one case of phthisis originated at the place; but two or three cases, which were imported, rapidly improved under treatment; phthisis, however, is very prevalent and very fatal among the Indians."

Of 219 cases of disease recorded at the military post during four years, 1870–74, there was one only of phthisis. The most prevalent diseases were rheumatism, catarrhal and diarrhœal diseases.

At Fort Vancouver, situated on the Columbia River, one hundred and twenty miles from its mouth, latitude 45° 40′ north; longitude 48° 27′ west; on information furnished by Surgeon-General J. K. Barnes, Surgeons J. H. Bill and R. H. Alexander, U. S. Army,[2] for the same period, of 1,091 cases of disease recorded, three were for consumption. The most prevalent diseases were catarrh and bronchitis (223 cases), diarrhœal diseases and rheumatism.

According to the report[3] of Surgeon C. H. Alden, U. S. Army, from Fort Walla Walla, in the southeastern part of the Territory, latitude 46° 4′ north; longitude 40° 21′ west; 865 feet above the level of the sea, the prevalent diseases at the post and in the vicinity are malarial and rheumatic affections. Of 288 recorded cases of disease at the post, there were for diarrhœa and dysentery 35, catarrh and bronchitis 30, other local causes 101, for rheumatism and phthisis none.

The climate of Oregon in the interior, and at an altitude of 4,000 feet and upwards, as observed by Assistant Surgeons Charles Styer, R. Knickerbocker, and C. B. Byrne, U. S. Army, from Camp Harney, latitude 43° 30′ north; longitude 41° 27′ west; and Assistant Surgeon Henry McEldevy, U. S. Army, from Fort Klamath, in southwestern Oregon, latitude 42° 39′ 4″ north; longitude 44° 40′ west; is very severe in the winter months; and frosts during every month in the year. Of 836 cases of disease recorded at the first-mentioned of these posts during four years, 1870–1874, three were for consumption; and at the second, for the same period, of 659 cases, 14 were for consumption. Catarrh and bronchitis, diarrhœal diseases and rheumatism were prevalent. At Fort Stevens, situated upon the extremity of Point Adams, at the mouth of the Columbia River, on a low sandy spit, covered with a heavy growth of

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[1] Op. cit., pp. 463, 468.
[2] Op. cit. p. 488.
[3] Op. cit., p. 492.

of spruce and hemlock, Assistant Surgeon D. L. Huntington, U. S. Army, reports:[1]

"The climate is equable, much more so than on the same isothermal line of the Atlantic coast. The year is practically divided into a dry and wet season. The former embraces the months of May, June, July, August, and September, during which but little rain falls. The rains commence usually in October, and continue almost without intermission until May.

"Sudden or excessive changes of temperature are very uncommon. During the year 1873, the highest recorded temperature is 86°; the lowest, 24°. The average mean temperature of several years is about 54°.

"Snow and ice are not common, and generally, during the winters, vegetation is not entirely suspended.

"The annual rain-fall is excessive, and is confined to the wet season. During 1873, 77.80 inches fell, which is about the average.

"The prevailing winds of winter are southeast and southwest, occasionally northeast. The former are warm and humid; the latter, dry and cold. During summer, the prevailing wind is from the northeast."

Of 216 cases of disease recorded at the post during the four years' observation, two were for consumption. The most prevalent diseases were those classed under the head of "local diseases," but none particularly prominent.

In California alone, the climate extends over almost ten degrees of latitude. But that of the sea-shore is generally influenced by the temperature of the ocean. The cold current which flows out of Behring Strait and hugs the coast inside of the Kuro-sievo, or Pacific ocean-current, similar to the Gulf stream, has a temperature of from 52° to 54° the year round. From April to October, inclusive, north or northwest winds prevail, and almost daily during this period a deluge of cold, damp air, of nearly the same temperature as the ocean over which it has passed, is poured upon the land. It is commonly laden with mist in dense clouds, which it deposits at the foot of hills, and on the slopes of the high lands, or carries a short distance into the interior.

Wherever there is a break in the mountain wall which shuts off these mists from the sunny valleys of Middle California, the climate is, as nearly as possible, the opposite of the sea-coast climate in every respect; so effectually do the mountains shut off the basins of the interior.

Notwithstanding, it is remarkable to observe that of 6,792 cases of disease recorded at the military posts, during a period of four years, 1870–1874, in California near the sea-level—the greatest altitude being 397 feet—30, or one in 226.5, were for consumption; while of 422 cases recorded at the posts east of the coast chain of mountains, at altitudes

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[1] Op. cit., p. 484.

of 4,680 and 4,958 feet above the level of the sea, there were 3, or one in 140, for consumption.

Commencing at the south, the chain of mountains formed by the union of the sea-coast range and the Sierra Nevada completely shuts off the ocean climate, and instead of the moderately humid air of the western slope to the Pacific, there is on the eastern slope and basins of this region a climate of unusual dryness and of almost fiery severity, reducing the soil to a desert. Even the mountains which retain the snow till a late period in the season have a high temperature in the middle of the day, and the presence of snow on their summit in June is due rather to the great mass which has accumulated on them in winter than to the lowness of temperature even at such altitudes at this season.

The great altitude of the mountains near the Pacific coast is one of the most distinctible features of surface character exercising influence over the climate. Those near the coast are much broken; that is to say, they consist of overlapping groups, from forty to seventy miles wide, at an altitude nowhere exceeding 4,000 feet, from twenty to seventy miles from the coast. But at their crests, twenty to fifty miles further from the coast, some of the peaks reach an altitude of 10,000 feet. And the Sierra Nevada Mountains, of which the irregular coast chains and groups are off-shoots, from one hundred and ten to one hundred and fifty miles from the coast, attain a considerably greater average altitude, the highest peaks being 12,000 to 15,000 above the level of the Pacific. But these also are sufficiently near the coast to exercise considerable influence over the climate.

In San Francisco, and in most of the towns on the coast north of that port, the summer temperature is frequently too cool for comfort. In the nine degrees of latitude, between the mouth of the Columbia River and Monterey, the mean temperature of the year varies only three or four degrees, but the summers are hotter and the winters cooler in the northern part than in the southern.

Between the coast and the interior valleys, there is a large district under the joint influence of the ocean atmosphere and the forests, approximating the condition of Florida, with the additional influence of mountain peaks hard by, and consequently enjoying one of the most delightful climates in the world. This region is composed chiefly of the valleys surrounding the Bay of San Francisco, and expanding into the interior in every direction. The sea-breeze, with its clouds and abundant moisture, prevents these valleys from being parched with drought, tempers the fierceness of the heat, and moderates the cold of winter.

Except in the northern counties, there is nothing which can properly be called winter in this region, the year being divided into the rainy and dry seasons. Through the rainy season in San Francisco and on the coast generally (as may be seen by turning to the charts and records of

humidity), no more rain falls than in the Atlantic States during the summer.

In southern California:[1]

"The winter may be said to commence about November. During this season the days are usually warm, and the nights cold, the difference in temperature being very great. In the lowlands ice sometimes forms. The atmosphere is exceedingly dry, and very little rain falls during the winter. When the coast rains prevail in California, sometimes a few drops fall here. The climate is rendered somewhat disagreeable by occasional violent sand-storms, usually from the northwest. They can be seen approaching for some hours, gradually obscuring the sun; finally they burst with sudden fury, filling the air and everything around with fine dust. These sand-storms sometimes last three days; in the intervals between them no more delightful climate could be desired. Fires are necessary during these months, November to March, and heavy underclothing is required to protect the body from the sudden change of temperature which takes place after sundown.

"Spring commences about the last of February, and is without rain. The cotton woods and willows put forth new leaves, but, owing to the continued cold nights, the leaves do not mature before the middle of April. Fires are still required in the evenings and early mornings.

"The heat rapidly increases from the latter part of May, and in June, July, August, and September may be said to be intense. In the months of July and August (the rainy season in Sonora), clouds are seen passing to the northeast accompanied with rain, thunder, and lightning; occasionally they reach the vicinity of Yuma, and are most refreshing. During the months of April, May, and June, no rain falls; then, with the thermometer at 105°, the perspiration is scarcely seen upon the skin, and it becomes dry and harsh, and the hair crispy. Furniture put together at the north and brought here falls to pieces; travelling chests gape at their seams, and a sole-leather trunk contracts so that with difficulty the tray can be lifted. Furniture, to hold together, must be made of the very dryest timber. The extreme dryness of the atmosphere is observed in the ink that dries so rapidly upon the pen that it requires washing off every few minutes. A No. 2 'Faber' leaves no more trace on paper than a piece of anthracite, and it is necessary to keep one immersed in water while using one that has been standing in water for some time. Newspapers require to be unfolded with care; if rudely handled they break. I was called to inspect some commissary stores a short time ago, and the loss they had sustained was remarkable.

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[1] Report from Fort Yuma, on the Colorado River, 180 miles from its mouth; latitude 32° 23′ 3″ north; longitude 37° 33′ 9″ west; altitude 267 feet above tide water. Assistant Surgeons J. V. Lauderdale and George S. Rose. Op. cit., p. 559.

Twelve-pound boxes of soap weighed ten pounds. Hams had lost twelve per cent and rice two per cent of their original weight. Eggs that have been on hand for a few weeks lose their watery contents by evaporation; the remainder is thick and tough; this has probably led to the story that our hens lay hard-boiled eggs.

"The mercury gained the highest point last summer (1873) on the second day of July, when, for two hours, it stood at 132° in the shade. All metallic bodies were hot to the touch; my watch felt like a hot-boiled egg in my pocket; the cords on my grass hammock were like heated wires. At such times, if the wind is from the south, the air is like that from the mouth of a furnace, hot and ovenish.

"The effort to cool one's self with an ordinary fan would be vain, because the surrounding atmosphere is of a higher temperature than the body. The earth under foot is dry and powdery, and hot as flour just ground, while the rocks are so hot that the hands cannot be borne upon them. The parade is always hot at mid-day, and the story told of a dog that ran on three legs across it, barking with pain at every step, may be correct, though I have never seen it tried.

"This post, though not the most southerly, is the hottest military post in the United States; the highest temperature recorded in our books since 1850, when the post was established, is 119°, observed at 2.25 P.M., June 6th, 1859. A temperature of 100° may exist at Fort Yuma for weeks in succession, and there will be no additional case of sickness in consequence.

"The dress must be of the lightest, suitable to the temperature. The lightest woollen fabrics that are made should be worn next to the skin, or, if woollen is not borne well, cotton. The dress of the natives is very simple. The heavily-fringed kilt, made of the bark of the cottonwood, or woollen yarn in two divisions, which hardly come together at the hips, and worn about the loins, is the fashion which obtains among the Yuma women, while the men of this tribe encumber themselves with about two yards of muslin, and a belt or strap.

"Ice is never seen, not even on the coldest day in winter. I do not think it would be desirable to have the article in summer if it could be furnished. The water we drink is relatively cool at 60° to 75°, and is very refreshing.

"We have none of the malarial diseases incident to the cities of the Gulf of Mexico, or along the eastern seaboard. The heat depresses the already debilitated, and we miss the tonic effect of the cold weather; but those who come here in good health, and observe the ordinary rules for preserving it, will have nothing to fear from the high temperature.

"The influence of the great 'Colorado Desert' on the climate is more or less felt in all the counties comprising the southern half of the State. The desert is an immense oven where a hot and rarefied air is generated, which rages in hot blasts from time to time over these coun-

ties. The rain which waters the northern portion of Mexico does not travel across the desert, the moisture being taken up by the hot, dry air. These dry and desiccating currents exhaust also the moisture which comes down from the north in winter, so that there is a large rainless area on the southern border of the State which is year after year robbed of its moisture by the proximity of the desert. Geologists affirm that at one time the greater part of this desert was covered by the waters of the Gulf of California, and the theory is maintained that if the greater part were again submerged, hot winds would cease to rage over these southern counties, and as much rain would fall there as upon the northern part of the State. The climate would then be cooler and more equable. Much of the land comprising the desert has been found to be below the level of the low tides of the Gulf, and practical engineers maintain that at comparatively small expense this great desert furnace can be cooled by covering it with water. The theory is that, were the desert a sea, it would send up a column of atmosphere charged with moisture, which, meeting the colder currents from the ocean, would precipitate frequent showers, and thus change large tracts of the country from barrenness to fertility."

Dr. A. B. Stuart, a former resident of Winona, Minnesota, in a paper on "Santa Barbara as a Health Resort," states that, from personal observation

"Almost any desirable peculiarity, either in climate or geographic location, from sea level to 3,500 feet of altitude, for invalids can be obtained in Santa Barbara and vicinity. If the coast is found too cool and damp, as it is at times during the months of March, April, and May, by going back from two to six miles from the ocean, numberless sheltered nooks can be found, among the foot-hills, in the cañons or on the mountain side, where the air is both warmer and dryer.

"The middle of the 'warm belt' is said to be somewhere between 200 and 600 feet above sea level, in which the old Mission of Santa Barbara is situated, it being 300 feet above the ocean and two and one-half miles distant therefrom; yet it does not receive the full benefit that the altitude should give it, in consequence of a peculiar geographical northwest wind which occasionally visits certain exposed localities. But, by going from one to three miles farther from the coast, that wind is avoided.

"At the summit station in the San Marcus Pass, on the stage road over the Santa Ynez Mountain, at an elevation of about 2,500 feet, the air is so dry during the summer season that invalids can camp out and sleep upon the ground. Dr. E. N. Wood, a gentleman of culture and experience, whose life in a hopeless decline, pulmonary phthisis, was prolonged several years by a residence in this valley, spent a portion of the last year of his life camping out in that picturesque locality, with great satisfaction to himself. He frequently preferred taking his

blankets and sleeping in the open air just outside the door of his tent.

"If a hot and very dry climate is sought, the Ojai Valley will furnish the desideratum. It is a basin inclosed with a rim of mountains. Nordhoff is the only village in the valley, and contains two hotels and several boarding-houses. Is fifteen miles from the ocean and forty-five from this city by the present road, but will soon be brought within thirty miles by a road shortly to be opened. Altitude of Nordhoff, 900 feet. Prof. Bennett, of the University of Edinburgh, writing of phthisis pulmonalis, says: 'Much has been written of climate, but the one which appears to be best is that which will enable the patient to pass a few hours every day in the open air without exposure to *cold* or vicissitudes of temperature on the one hand, or the *extreme heat* on the other,' or words to that effect.

"I know of no geographical boundary of the same number of miles that so fully complies with the above requirement as Santa Barbara, with her sheltered nooks and the Ojai Valley. As proof of what I have said, so far as it pertains to this city, I give the following summary of a daily record kept for one year, by L. Bradley, Esq., of Aurora, Ill., who came here for a temporary residence on account of advanced phthisis, he having had severe and frequent hemorrhages. 'During the year there were 310 pleasant days, in which an invalid could be out-of-doors five or six hours each day with safety and comfort; 29 cloudy days, upon 20 of which an invalid could be out-of-doors for a short time; 12 showery days, upon 7 of which an invalid could be out an hour at a time several times each day; 10 windy and 5 rainy days, confining an invalid to the house the entire day.' The time of observation extended from February 1st, 1876, to February 1st, 1877. Since all Mr. Bradley's pecuniary interests are in the Eastern States, the charge of 'interested in it,' made by the writer referred to, cannot apply to his statements. Through the kindness of L. N. Dimmick, M.D., formerly of Ottawa, Ill.—a phthisical invalid unable even here to pursue the active duties of his profession, but who has been for five years a most diligent and trustful observer and recorder of events that pertain to this place as a sanitarium—I am permitted to draw liberally upon the material furnished by his records and note-book. He says: 'The average temperature for three years has been, at 7 A.M., 58°, at 2 P.M. 69°, and at 9 P.M. 57°, showing that mid-day was 11° warmer than morning, 12° warmer than evening. The following are the days in each year mentioned during which the temperature fell below 43° above zero and rose above 83°.

1873	below 43°	on	7	days,	above 83°	on	1	day.
1874	"	"	" 9	"	"	"	"	6	days.
1875	"	"	" 4	"	"	"	"	22	"
1876	"	"	"17	"	"	"	"	4	'

Average below 43°, 9¼ days; average above 83°, 8¼ days.

"The mean relative humidity for the year ending April 1st, 1877, was 69.41," which compares favorably with that of San Diego as given by the above-mentioned correspondent at 72.4. Carrying the comparison of the relative humidity beyond the Rocky Mountains, the showing is still more favorable for Santa Barbara:

Mean Relative Humidity for Santa Barbara, 69.41 per cent.
" " " " Philadelphia, 80 per cent.
" " " " New Orleans, 83.50 per cent.

And taking a still wider range for the difference in the mean temperature of the months of January and July, the comparison is no less favorable.

"Mean temperature of January and July:

	Jan.	July.	Difference.
Santa Barbara, Cal	53.25	68.20	14.95
San Diego, Cal	53.55	70.32	16.77
St. Augustine, Fla	56.79	80.91	24.12
Jacksonville, Fla	55.51	81.73	26.22
Akin, Geo	47.05	79.91	32.85
Galveston, Texas	51.55	84.42	32.87
Denver, Col	26 57	72.68	46.11
Algiers	52.	75.	23.
Mentone	40.	73.	33.

"Blodget's Climatology has furnished part of my data, and the balance is from sources no less trustworthy. By census of Santa Barbara County, taken from the records in the Court-house, in 1870, the population was 7,984, in which the number of deaths from consumption, phthisis pulmonalis, was only five, or one death by consumption in 1,596 of a population. The number of deaths from all causes was sixty-three, so that a little less than one-thirteenth of the mortality was from phthisis. The total mortality was one in 126 of the inhabitants of the county. This was before the tide of invalid immigration had fully set in, and gives a fairer showing as to the climatic effect upon phthisical patients than at a later day, when so many come in the far-advanced stages of the disease, beyond the remedial agency of climate or anything else. But if there is hope, it is to be found in Santa Barbara or in the valley of the Ojai, on the plains of Anaheim, the historic valley of San Gabriel, so graphically described by the above-mentioned correspondent, as I can bear testimony from personal observation.

"Santa Barbara is free from that extreme heat that so frequently increases the colliquative diarrhœa or disease of the bowels so often accompanying phthisis; and fever and ague, or other indigenous malarious diseases are unknown. During what months of the year a sojourn here on the coast will be most beneficial to the invalid, phthisis, or whatever it may be, he must determine for himself—first upon the advice of those

who have made the subject a study, and secondly, his own personal experience; for what is beneficial to one may not be to another, although apparently in the same condition. But as a rule, the spring months, March, April, and May, are *most variable*, and have more unpleasant days than other portions of the year. At this season, many invalids seek the Ojai Valley, which furnishes a most pleasant and beneficial retreat for those afflicted with a sensitive condition of the mucous membrane of the air passages. A few remain in the valley during the summer, while others prefer to spend the year in Santa Barbara, enjoying the usually good hotel accommodations of this city. All seasons of the same months are not alike; but the past January and February (1877), as I found them in the city and vicinity of Santa Barbara, were most delightful, combining all the climatic advantages that any place could offer the nervously-depressed invalid, either from phthisis or any other cause." [1]

Of mineral springs on the Pacific Slope, beginning with Sitka, there are said to be *warm sulphur springs* or geysers, 96° to 104° Fahr., about twenty miles from the City of Sitka, which were much frequented by the Russians for the cure of syphilitic and rheumatic affections before this territory was ceded to the United States, but no analysis of the water has been published, by which the properties of the water may be verified.

Wilhoit's Soda Springs, Calcamas County, Oregon, is an unusually valuable alkaline water.

One pint contains (J. H. Veach, M.D.):

Solids.	Grains.
Carbonate of soda,	10.946
Carbonate of magnesia,	10.665
Carbonate of protoxide of iron,	0.750
Carbonate of lime,	4.028
Chloride of sodium,	25.125
Sulphate of soda,	0.425
Sulphate of magnesia,	0.810
Iodine,	trace
Total,	52.749

Carbonic acid gas, 42 cubic inches.

The amount of carbonic acid they contain renders them very exhilarating. They are mildly laxative and diuretic.

The springs are salubriously situated, thirty miles northeast from Salem.

Lower Soda Spring is situated in the Cascade Mountains, Linn County. They are said to resemble the Wilhoit, but no analysis has been made.

[1] The Sanitarian, vol. v., pp. 349–52.

Hot Springs, 184° Fahr., in Lane County, about one hundred miles from Springfield, on the Oregon and California Railroad, the nearest railroad station; and *Warm Springs,* in Cook County, on an Indian reservation of the same name, have been reported, but no analysis has been published.

Des Cehutes Hot Springs, in Wasco County. One pint contains (143° and 145° Fahr., L. M. Dornbach and E. N. Horsford):

SOLIDS.	Grains.
Carbonate of soda,	4.312
Chloride of potassium,	0.250
Chloride of sodium,	2.552
Chloride of magnesium,	0.152
Sulphate of soda,	1.183
Sulphate of lime,	0.228
Silicate of soda,	1.025
Iron,	trace
Total,	9.702
Carbonic acid, 2.82 cubic inches.	

California excels in the number of her mineral springs, of almost every variety, and some of them are of great value; yet comparatively few of the waters have been analyzed.

California Seltzer Springs, in Mendocino County, twelve miles by stage from Lanel, on California and Northern Pacific Railroad, is an excellent *alkaline* water, closely resembling the imported water after which it is named. One pint contains (61° F., H. G. Hanks):

SOLIDS.	Grains.
Carbonate of soda,	7.598
Carbonate of magnesia,	11.118
Carbonate of lime,	1.938
Carbonate of iron,	0.567
Chloride of sodium,	1.478
Alumina,	0.075
Silica,	0.729
Total,	22.503
Carbonic acid, 45 cubic inches.	

Vichy Springs, New Almaden, Santa Clara County, about sixty miles south from San Francisco, are also named with reference to the resemblance of the water to the imported Vichy. One pint contains (Second Biennial Report of State Board of Health):

SOLIDS.	Grains.
Carbonate of soda,	17.440
Carbonate of lime,	2.878
Chloride of sodium,	4.200

Solids.	Grains.
Sulphate of magnesia,	1.500
Sulphate of lime,	5.250
Oxide of iron,	0.600
Silica,	trace
Total,	31.868

Carbonic acid, 29.85 cubic inches.

Adams Springs, in Lake County, from Callistoga or Lower Lake. One pint contains:

Solids.	Grains.
Carbonate of soda,	7.129
Carbonate of magnesia,	12.378
Carbonate of iron,	0.064
Carbonate of lime,	3.589
Chloride of sodium,	0.514
Potassa salts,	traces
Nitric acid,	traces
Silica,	0.902
Organic matter,	0.351
Total,	24.927

Carbonic acid, 38.00 cubic inches.

Congress Spring, Santa Clara County, on the San José branch of the Central Pacific Railroad, about forty miles south from San Francisco, is a *muriated-alkaline* water. One pint contains (50° Fahr.):

Solids.	Grains.
Carbonate of soda,	15.418
Carbonate of iron,	1.753
Carbonate of lime,	2.161
Chloride of sodium,	14 894
Sulphate of soda,	1.517
Silica, alumina, and trace of magnesia,	6.235
Total,	41.978

This water is extensively on the market in California, charged artificially with carbonic acid, and very agreeable.

Fry's Soda Spring, Liskiyon County, near Oregon Railroad, is a *chalybeate* water, highly impregnated with carbonic acid, sparkling like soda water. No analysis.

Napa Soda Springs, in Napa County, by steamer from San Francisco to Vallejo, thence by Valley Railroad to Napa City, and stage to the springs; *alkaline chalybeate.* One point contains (Langweert):

Solids.	Grains.
Carbonate of soda,	1.138
Carbonate of magnesia,	3.265
Carbonate of iron,	0.980
Carbonate of lime,	1.360
Chloride of sodium,	0.650
Sulphate of soda,	0.230
Silicic acid,	0.085
Alumina,	0.075
Loss,	0.310
Total,	8.093

Highland Springs, Lake County, from San Francisco via Cloverdale or Calistigo. Situated at an altitude of 1,740 above the level of the sea, and protected by the mountains from sea-coast winds.

One pint contains.	Seltzer Spring. 64.8° F. W. B. Rising.	Dutch. 70.5° F. W. B. Rising.	Magic. 82.4° F. W. B. Rising.
Solids.	Grains.	Grains.	Grains.
Carbonate of soda	1.109	1.590	1.887
Carbonate of potassa	0.047	0.073	0.053
Carbonate of magnesia	2.584	5.010	5.204
Carbonate of iron	0.115	0.122	0.098
Carbonate of manganese	trace	trace	trace
Carbonate of lime	4.345	4.975	4.377
Chloride of sodium	0.090	0.207	0.160
Silica	0.655	0.890	0.924
Alumina	0.195	0.014	0.021
Organic matter	trace	trace	trace
Total	9.140	12.881	12.724
	Cubic in.	Cubic in.	Cubic in.
Free carbonic acid	26.5	23.1	19.6

Borax Springs, in Lake County, by cars from Vallejo to Calistoga, thence by stage to Lower Lake, and by private conveyance. One pint contains (J. A. Veatch):

Solids.	Grains.
Carbonate of soda,	6.671
Carbonate of ammonia,	8.613
Chloride of sodium,	10.577
Iodide of magnesium,	0.011
Biborate of soda,	12.911
Alumina,	0.157
Silicic acid,	1.029
Matters volatile at red heat,	8.221
Total,	48.190

Carbonic acid, 9.60 cubic inches.

"These substances being calculated as anhydrous salts and borax, containing 47 per cent of water when crystallized, cause 12.911 grains in the above analysis to be equal to 24.417 of commercial borax. There are probably no springs in the world which contain so large a per cent of ammoniacal salts as these."[1] Borax Lake, which was discovered by Dr. Veatch in 1859, is two miles south of the Springs. When filled up by the winter rains, it is over a mile long and nearly half a mile wide, and the mud at the bottom contains 18 per cent of borax.

St. Helena White Sulphur Springs, in Napa County, twelve miles distant by rail from Calistoga Springs, are *saline-sulphur* waters, with sufficient sulphate of soda to render them mildly aperient.

One pint contains.	No. 2 89.6° Fahr. Prof. Le Coute.	No. 6 86° Fahr. Prof. Le Coute.	No. 7 69 8° Fahr. Prof. Le Coute.
SOLIDS.	Grains.	Grains.	Grains.
Carbonate of magnesia.............	0.077	0.070	0.545
Carbonate of lime.......	0.156	0.301	0.695
Chloride of sodium	2.715	2.955	0.779
Chloride of magnesium	0.108	0.277	0.081
Chloride of calcium...	0.145	0.107	0.097
Sulphate of soda	1.032	1.416	1.685
Sulphides of soda and calcium.. ...	0.331	0.231	0.232
Total............	4.564	5.357	4.114
	Cubic in.	Cubic in.	Cubic in.
Sulphuretted hydrogen....	0.76	0.53	trace

Of *thermal springs* in California there is a large number, among the most noted of which are the *Santa Barbara Hot Sulphur Springs.* They are situated at the head of a deep cañon about five miles north of Santa Barbara, at an elevation of 1,400 feet above the level of the sea. There are seven springs, evidently containing different quantities of sulphur and sulphuretted hydrogen, though no reliable analysis is obtainable, adaptable to different purposes, drinking or bathing. The temperature is from 112° to 117°, and they have been found very efficacious in the treatment of some skin diseases, chronic rheumatism, and other diseases amenable to sulphur waters.

Calistoga Hot Springs, in Napa County, from Vallejo direct by rail. There are about seventy springs, varying in temperature from 95° to 212° F., and distributed over an area of upwards of one hundred acres. The waters are used almost exclusively for bathing and swimming, the appointments being elaborate. There are also *moor* or *mineral mud baths,* similar to those of Marienbad and Franzensbad, in Bohemia. The

[1] "The Natural Wealth of California."

region round about is full of interest, and Calistoga the point of departure for many interesting places. The *Petrified Forest* is about five miles distant to the southwest.

Paso Robles Hot Springs, San Luis Obispo County, from San Francisco by rail to Soledad, one hundred and forty-three miles, thence by stage to the Springs.

One pint contains.	Main Spring. 112° Fahr. Prof. Thos. Price.	Mud Spring. 122° Fahr. Prof. Thos. Price.
SOLIDS.	Grains.	Grains.
Carbonate of soda	3.364	0.543
Carbonate of magnesia	0.057	0.323
Chloride of sodium	2.830	10.047
Sulphate of potassa	0.092	trace
Sulphate of soda	0.818	4.281
Sulphate of lime	0.334	1.864
Protoxide of iron	0.037	.....
Iodides and bromides	traces	.....
Alumina	0.023	.....
Silica	0.046	0.116
Organic matter	0.171	0.361
Total	8.072	17.535
GASES.	Cubic in.	Cubic in.
Carbonic acid	2.31	10.53
Sulphuretted hydrogen	Saturated.	Saturated.

These springs are situated in a valley on the northern slope of the Santa Lucia Mountains, and are well appointed. There are over twenty sulphur baths, and a mud-bath for the thorough application of sulphur baths to all the conditions desired.

Arrow-head Hot Springs, San Bernardino, in the county of the same name, are nine miles from Colton, a station on the Southern Pacific Railroad, two thousand feet above the level of the sea, in the midst of magnificent scenery. The temperature of the spring waters is from 140° to 210° F.; no analysis; and the surroundings unimproved. The situation has remarkable natural advantages at all seasons, and if the springs are of value, it seems destined to be one of the most desirable resorts in the State.

Skagg's Hot Springs, in Sonoma County, twenty miles by stage from Healisburg, a station on San Francisco and Northern Pacific Railroad, are said to contain sulphur, iron, and borax; temperature 128° to 140° Fahr. No analysis. "The cañon in which the hotel is located contains several trout streams affording excellent fishing," and other surroundings are described as attractive.

The Geyser Spa Springs, in Sonoma County, are scarcely less wonder-

ful than those of Wyoming. They are reached from San Francisco by rail to Cloverdale, thence twelve miles by stage. They are situated in a cañon half a mile long, from one to two rods width at the bottom, and fourteen hundred feet in depth. From the bottom of this the banks ascend at an angle of forty-five degrees, their surface for the most part being covered with a whitish residuum of extinct geysers—bleached by the sun and rains of scores of summers and winters. But all along at wide intervals are jets of steam from springs still bubbling in hidden recesses. The water is said to contain alum, iron, sulphur, and Epsom salts. It is of all temperatures, from 90° to steam heat. The only analysis obtainable is the following:

One pint contains (F. W. Hatch, M.D., "Second Biennial Report of California State Board of Health"):

SOLIDS.	Grains.
Carbonate of soda,	2.036
Carbonate of magnesia,	0.726
Carbonate of iron	0.475
Carbonate of lime,	0.570
Chloride of sodium	1.245
Sulphate of soda,	0,425
Silica,	0.275
Loss,	0.040
Total,	5.792

Harbines Springs, Lake County, twenty miles north of Calistoga and four miles west of Middletown, in a wild and picturesque cañon of the Coast Range Mountains.

This water is *thermal,* 118° to 120° Fahr., and said to be highly charged with sulphur, soda, iron, magnesia, the sulphur predominating. No analysis. Used chiefly for bathing purposes, and of considerable repute for such diseases as this class of waters is usually prescribed.

Paraiso Springs, Monterey County, at an elevation of 1,400 feet above the level of the sea, at the head of a cañon in the Coast Range Mountains, in view of the Salinas plains below. Accessible via Southern Pacific Railroad to Solidad, one hundred and fifty miles, thence seven miles by stage. High mountains rise on three sides of the springs, while the plains below, traversed by the Salinas and Arroyo Seco Rivers, extend to the Gabilan Mountains beyond. The region is exceedingly picturesque and healthy, and of growing repute as a resort for consumptives. The waters are *thermal,* and said to resemble the famous Carlsbad, of Germany. One pint contains (118° Fahr.):

SOLIDS.	Grains.
Carbonate of soda,	0.52
Carbonate of lime,	0.17
Chloride of potassium,	0.04
Chloride of sodium,	0.44
Sulphate of soda,	4.44
Sulphate of lime,	0.54
Magnesia,	trace
Alumina and iron,	0.20
Silica,	0.32
Organic matter,	0.65
Total,	7.32

There is also a warm *sulphur* spring, 114° Fahr., said to contain a large percentage of sulphate of soda, sulphate of lime, and carbonate of magnesia, with peroxide of iron and sulphate of potassa. No analysis. "Medicated" and mud baths are also provided, and in popular use.

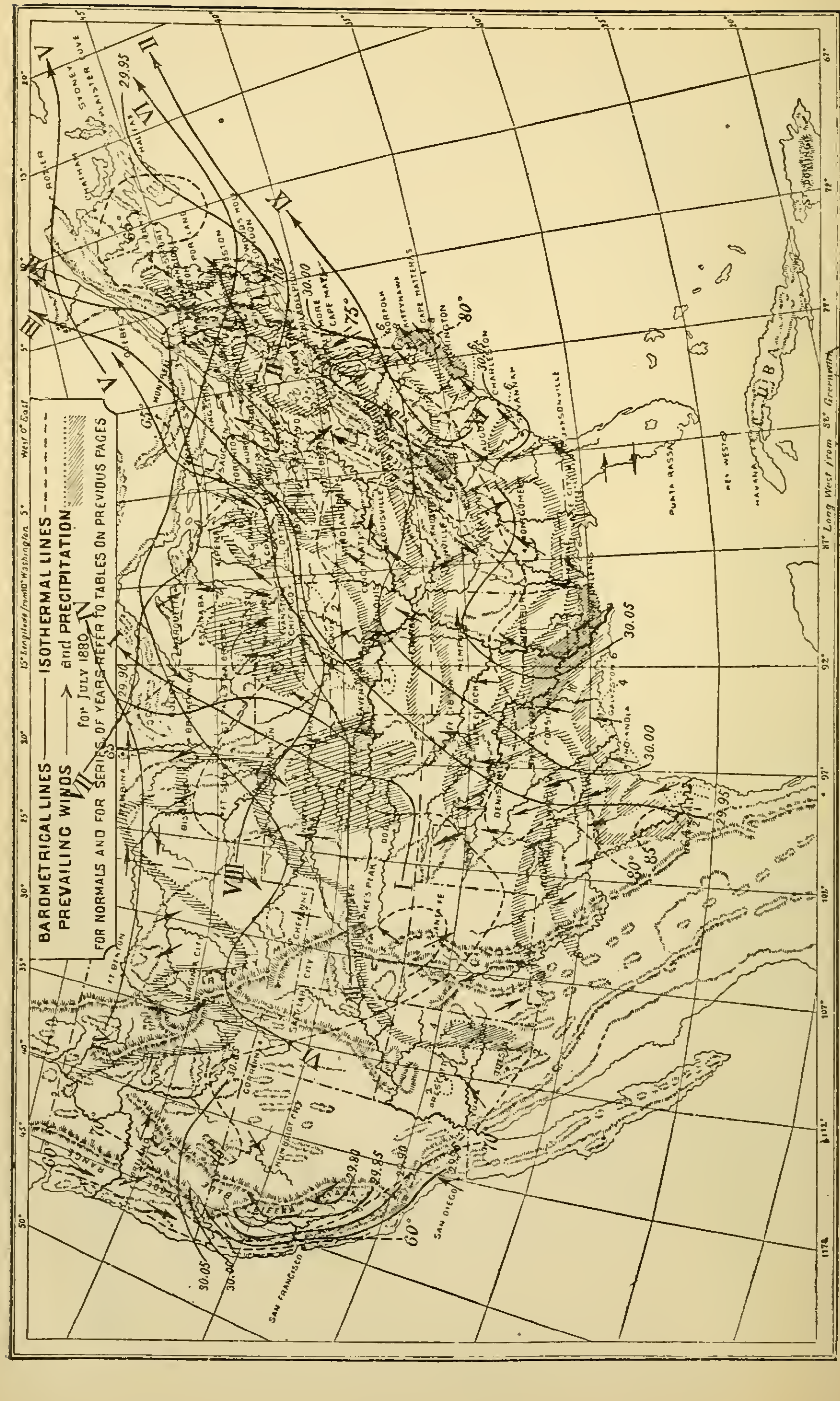
Seigler Springs, in Lake County, accessible from San Francisco and Sacramento by boat to Vallejo, thence by rail to Calistoga, and thence by stage to Seigler Valley. Seigler Valley is a basin surrounded by picturesque mountains from 1,500 to 4,000 feet above the level of the sea, on one of which the springs are situated. The spring waters are of various temperatures, from icy coldness to boiling heat, and of "different flavors and colors," but no analysis has been made. The region is salutary, but deficient in local improvements.

Summit Soda Springs, Alpine County, accessible from San Francisco via Central Pacific Railroad, two hundred and forty-three miles, to Summmit Station, thence to the Springs by private conveyance. Altitude 7,000 feet above the level of the sea, surrounded by mountains from 12,000 to 15,000 feet altitude, and said to be an exceptionally desirable resort for those to whom a rarefied air is desirable.

One pint of the water contains ("Second Biennial Report California State Board of Health"):

SOLIDS.	Grains.
Carbonate of soda,	1.187
Carbonate of magnesia,	0.525
Carbonate of lime,	3.751
Chloride of sodium,	3.277
Oxide of iron,	0.218
Potassa,	trace
Silica,	0.257
Alumina,	0.218
Total,	9.433

Carbonic acid, 23.29 cubic inches.



BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
for JULY 1880
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES

CHAPTER XIX.

THE WEATHER.[1]

MONTHLY AND ANNUAL MEAN PRESSURE, TEMPERATURE, HUMIDITY, PRECIPITATION, PREVAILING WINDS AND STORMS, AND ATMOSPHERIC ELECTRICITY.

It will be observed, in the series of charts, one for each month, the range of the barometer is shown by continuous *isobaric* or barometrical lines, ————————, and the course of storms by the termination of such lines in arrow-heads, and roman numerals; the temperature is shown by broken *isothermal* lines, — — — —; the course of the winds by arrows; and the precipitation or rainfall by dotted lines and circles, shaded, with numbers designating the days of the month on which the rain-fall occurred.

The Charts he represented are the combined observations of the Signal Service for each month respectively; but for a full appreciation of the information they convey, they should be studied in conjunction with the tabulated statistics of their several parts for a series of years, in Chapter XIV.

1. MONTHLY WEATHER REVIEW, JULY, 1880.

BAROMETRIC PRESSURE.

The general distribution of atmospheric pressure, as reduced to sea-level, for the month of July, 1880, over the United States and Canada is shown by isobaric lines on the Chart. At a few out-lying stations the means are given in figures indicating English inches. The pressure is found to preserve much the same general distribution that it had during June, the regions of highest barometer being over the Southern States and Northern Pacific region, while the lowest barometer means are to be found in the Red River of the North and Sacramento valleys.

Departures from the normal values for July.—The means for the present month, when compared with the average July means for the past years, show a remarkable uniformity. Along the immediate Atlantic

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[1] Abstract from Reports of Gen'l W. B. Hazen, Chief Signal Officer, U. S. Army 1881.

and Texas coasts from Iowa to lower Michigan, and in the Rocky Mountains the pressure is slightly below the normal, the greatest deviations being 0.05 of an inch at Charleston, Chicago, and on the summit of Pike's Peak and 0.06 at Wood's Holl; elsewhere the means are slightly above normal, the largest excesses being 0.04 inch at Cairo, Cincinnati, Detroit, and Albany, and 0.06 at Duluth.

Barometric ranges.—The local barometric ranges, as reduced to sea-level, have been exceedingly small over the entire country. They are least along the southern border and increase very slowly northwards.

Areas of high barometer.—Eight areas of high barometer are described. None of them present any very interesting features. The maximum pressures, as reduced to sea-level, over the United States west of the Rocky Mountains, were 30.48 at Umatilla and 30.37 at Portland during the presence of high area No. IV., and, east of the Rocky Mountains, 30.30 at Denver during the presence of the same area, and 30.29 at Marquette during the presence of area No. VIII. The lowest temperatures of the month, in general, accompanied areas Nos. V. and VIII.

Areas of low barometer.—Twelve areas of low barometer are described, but apart from the local thunder and hail storms, by which some of them were accompanied, are devoid of any special interest. Although the pressure along the Pacific coast during the early history of low areas Nos. III., IV., VI., and XII., experienced decided decrease, it has not been possible to trace any of these areas back to the Pacific. With the exception of the centres of areas No. IX. and XI., both of which—the latter during the whole and the former during the early portion of its history—were very poorly defined, the tracks of all the centres lie to the north of the 35th parallel. No. IV. as area No. X., moved slowly eastward, with its centre to the south of Newfoundland, but on the 29th it had apparently dissipated. Thence to the end of June, light winds and moderate pressures were reported.

TEMPERATURE OF THE AIR.

The mean temperature of the air for July, 1881, is shown by isotherms. The temperature during July was *below the normal* over the whole of the United States, except along the Atlantic coast and at San Francisco. For the normal temperatures, refer to tables, Chapter XIV. This, in connection with the average high mean temperatures recorded for the majority of districts east of the Rocky Mountains since the month of October, 1878, is very interesting.

PRECIPITATION.

The general distribution of rain-fall, for July, 1880, is shown on the chart as accurately as possible, from about 500 reports. The table on this chart shows the average precipitation for the several districts compared with the normal values. The rain-fall has been above the nor-

mal along the Gulf and Atlantic coast, in the St. Lawrence Valley and Upper Lake region, about normal over the Lower Lakes and Lower Missouri valley, and below normal elsewhere. The characteristic features of the rains during the month have been (1) their local nature, (2) their short duration, and (3) their copiousness. Thus, in Kansas and Missouri, while heavy rains fell during the first few days of the month, during the latter part of the month both States suffered from drought. In the paragraph on specially heavy rains, some remarkable records will be found, among which may be noted a heavy rain-fall of 1½ inches in 8 minutes at Paterson, N. J.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 11 to 19; Middle Atlantic States, 11 to 18; South Atlantic States, 9 to 19; Eastern Gulf States, 11 to 21; Western Gulf States, 7 to 14; Ohio Valley and Tennessee, 6 to 16; Lower Lake region, 10 to 19; Upper Lake region, 13 to 21; Upper Mississippi Valley, 8 to 14; Lower Missouri Valley, 9 to 12; Red River of the North Valley, 8 to 11; Eastern Rocky Mountain slope, 7 to 11; Texas, 4 to 16, Rocky Mountains, 7 to 24; Middle Plateau, 0 to 4; California, 0 to 2; Oregon, 3 to 9.

Cloudy days.—The number varies in New England from 9 to 14; Middle Atlantic States, 5 to 12; South Atlantic States, 5 to 16; Eastern Gulf States, 2 to 12; Western Gulf States, 2 to 10; Ohio Valley and Tennessee, 3 to 10; Lower Lake region, 3 to 8; Upper Lake region, 1 to 9; Upper Mississippi Valley, 2 to 8; Lower Missouri Valley, 2 to 5; Red River of the North Valley, 2 to 3; Eastern Rocky Mountain slope, 3 to 9; Texas, 3 to 16; Rocky Mountains, 2 to 10; Middle Plateau, 1 to 4; California, 0 to 3.

Hail.—Hail fell frequently throughout the month. At Big Creek, Mo., 1st; Wright Co., Mo., 1st; Springfield, Ill., 1st; Dongola, Union Co., Ill., 1st; Harrisonville, Mo., 2d; Cheyenne, 3d; Statesville, N. C., 14th; Wellsboro and Potter Co., Pa., 16th; Massahessic, N. H., 16th; Manchester, N. H., 16th; Genoa, Neb., 17th; Rochester, N. Y., 18th. Great damage was caused to crops near Spenceport, Lewiston, and Gasport; Trenton, N. J., 20th; Medina, Mich., 23d; Norwalk, O., 23d; Waupaca, Wis., 26th; Stephen's Point, Wis., 26th; Buzzard's Bay, Monument Beach, and Agawam, Mass., 29th; Fort Adams, R. I., 29th.

Snow fell on the summit of Pike's Peak, 9th, 10th, 13th to 17th, 19th, 20th, 21st, 23d to 26th, 28th. On the summit of Mount Washington, 29th.

Droughts.—*New York:* Waterburg, 1st to 10th, drought severe. *Massachusetts:* Westboro, 1st to 12th, great need of rain. *Illinois:* Augusta, 20th to 30th, very dry. *Kansas:* Wellington, 21st to 31st; all vegetation suffering. *Georgia*: Gainesville, 31st, crops suffering severely; *Missouri:* Louisiana, 31st, cisterns generally empty and creeks dried up; *Glasgow,* 31st, many springs stopped running. The Missouri weather

service reports drought very severe in the north, northeast, and central sections of the State, vegetation damaged.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, from 62 to 87; Middle Atlantic States, 59 to 88; South Atlantic States, 62 to 80; Eastern Gulf States, 65 to 73; Western Gulf States, 64 to 76; Ohio Valley and Tennessee, 60 to 76; Lower Lake region, 61 to 71; Upper Lake region, 67 to 77; Upper Mississippi Valley, 61 to 69; Missouri Valley, 59 to 62; Red River of the North Valley, 69 to 73; Eastern Rocky Mountain slope, 54 to 73, Texas, 62 to 77; Middle Plateau, 17 to 33, California, 31 to 82; Oregon, 57 to 69; *High stations* report the following averages not corrected for altitude: Pike's Peak, 71; Mount Washington, 82; Virginia City, 37; Denver, 47, and Santa Fé, 40.

WINDS.

The *prevailing directions of the wind* during July, 1880, is shown by arrows, flying with the wind, on the chart. To the east of the Rocky Mountains the predominating winds have been *southerly*, with an easterly trend over Texas, and a westerly one from the Eastern Gulf and Atlantic coasts to the Lake region. At the Rocky Mountain stations, over the Middle and Northern Plateau districts and North Pacific region, the directions are northwesterly. On the summit of Mount Washington, N. H., the direction is N.W., and the continuous record of the wind velocity shows a total monthly movement of 17,943 miles; the maximum hourly velocity during the month was N.W., 72 miles on the 10th. The same data for the summit of Pike's Peak is S.W., 8,493 miles, and S.W., 44 miles on the 10th. Maximum velocities exceeding 50 miles per hour were recorded at Umatilla (S.W., 52, on the 18th); North Platte (N.W., 80, on the 3d); and Chincoteague (S.W., 53, on the 1st).

Local storms.—Jacksonburg, Ohio, 2d, 4 P.M., small tornado passed two miles south of village, in a direction from S.W. to N.E.; width of track about 60 rods. "There were two inverted cones of vapor, one reaching from the clouds nearly to the earth, and then joining the apex of the lower one, extending upward from the ground. During its passage it was accompanied by a noise similar to the violent escape of steam. Sheaves of wheat and many other objects were drawn upwards and quickly lost sight of. The ground over which the storm passed appeared as if drenched by a flood." Cairo, Ill., 2d, 1.35 P.M, very heavy windstorm, lasting about 15 minutes, unroofing buildings and blowing down fences and trees. Chattanooga, Tenn., 2d, severe wind-storm, blowing down trees and fences. 3d, 6.25 to 6.47 P.M., severe N.W. storm,

during which the wind reached a velocity of 60 miles per hour for a period of 5 minutes, and averaged 48 miles for 15 minutes, unroofing buildings and uprooting trees; damage $1,500. Reports from Walker and Catoosa Counties, in northern Georgia, show exceedingly violent storms on this date, and great loss to agricultural interests. Columbia, S. C., 5th, violent tornado, unroofing buildings, uprooting trees, and destroying crops and fences. Clear Creek, Neb., 7th, 4.30 P.M., violent tornado approached from the southwest, passing about 3 miles north of station; 15 to 20 buildings were destroyed and great damage caused to crops. A large quantity of water was reported to have been taken out of the Platte River as the storm crossed it. Hanover, N. H., 16th, afternoon, severe tornado passed over southeastern part of village; "many buildings unroofed, several literally torn to pieces; trees all along the course of the storm were torn up by the roots, and large branches were twisted off and carried long distances. Course, S.W. to N.E., and path of destruction about 2 miles long and 200 rods wide." Portsmouth, N. C., 28th, 5.30 P.M., whirlwind struck the beach on south side of inlet, forming dense pillar of sand with rotary motion from right to left, and moving from S.E. to N.W., a distance of 3 miles. It then suddenly receded southeastward to the sea, where it disappeared. Diameter of whirl, 30 yards.

The observer at Yreka, Cal., reports the following heavy local storms near that place: July 5th, from 3.30 to 7 P.M., a violent storm passed from S. to N., about 4 miles wide, deluging the country with water; it then seemed to turn and pass to the S., and when about 4 miles east of this place, the precipitation was so great that the water seemed to roll along, through otherwise dry and nearly level gulches, to the depth of 4 or 5 feet, washing everything before it. The storm seemed to extend about 10 miles in length. Shasta River rose 2 feet in a few minutes. July 16th, heavy storm 15 miles northeast of this place; "cloud-burst," moving rocks weighing over 1,000 pounds; and on 17th, another heavy fall of water in the same place.

On the 18th, a severe thunder-storm passed eastward from northeastern Oregon into Idaho, during the progress of which a destructive "cloud-burst" occurred on West Butter (or Bitter) Creek, near Pendleton, which will be found noted under *Floods*. The observers at the surrounding Signal Service stations report as follows: Umatilla, Oregon, "sand-storm set in from the southwest at 3.50 P.M., and for 15 minutes the wind velocity reached 52 miles per hour; rain fell from 3.58 to 4.25 P.M., and several flashes of lightning were observed." Dayton, Wash., light rain from 3.30 to 5 P.M., "a heavy thunder-storm passed over the mountains about 15 miles south of station at 5 P.M." Pomeroy, Wash., "sudden heavy wind from 5.30 to 6 P.M." Boise City, Idaho, "light rain from 4.10 to 4.15 P.M., accompanied by zigzag lightning and loud thunder."

Waterspouts.—Key West, 12th, at 6 P.M. a waterspout formed to the southeast of station, in connection with a very heavy thunder-storm then prevailing. Kittyhawk, N. C., 18th, at 8.30 A.M. a waterspout formed over Albemarle Sound, 4 miles from station. It remained stationary until 8.55 A.M., and no rotary motion could be discerned. During this time, two smaller ones partly formed near to the main one, reaching nearly to the clouds, and, after swaying backwards and forwards for a short time, finally disappeared. Portsmouth, N. C., 28th, at 5.15 P.M. three waterspouts formed in Ocracoke Inlet, making a complete column of spray extending from sea to cloud, and moving slowly from S.W. to N.E. New Bedford, Mass., 29th, 5 P.M., a waterspout formed in the cove between Sconticut Neck and Mattapoisett Neck. It was at first very regular and straight, and connected with the western edge of a cloud, which was the scene of a thunder-shower of moderate extent and force. Diameter 30 to 40 feet, and altitude about 3,000 feet, composed of spray, which strongly contrasted with the dark cloud. It moved slowly to the southeast, and the portion midway from cloud to bay advanced faster than either the bottom or top, causing the column to bend forward and to drag the lower portion. It disappeared in about 20 minutes, being apparently drawn upward into the clouds.

Sand-storms.—Visalia, Cal., 25th. Burkes, Arizona, 7th, 10th, 15th, 17th, 24th.

ATMOSPHERIC ELECTRICITY.

Thunder-storms were reported in the following States from one or more stations on almost every day in the month: New York, New Jersey, Pennsylvania, Virginia, North Carolina, Georgia, Florida, Louisiana, Texas, Ohio, Michigan, Indiana, Illinois, Iowa, Wisconsin, Nebraska, Kansas, Colorado, and Washington Territory. In the following States they were reported on the dates indicated: *Maine:* 3d, 7th, 16th, 20th, 26th to 29th. *New Hampshire:* 15th, 22d, 26th to 28th. *Vermont:* 1st, 2d, 3d, 6th, 9th, 10th, 16th, 18th, 20th, 26th to 29th. *Massachusetts:* 6th, 9th, 10th, 15th, 16th, 20th, 26th, 29th, and 30th. *Connecticut:* 2d, 3d, 6th, 9th, 10th, 11th, 17th, 20th, 26th, and 27th. *West Virginia:* 5th, 10th, 19th, and 26th. *South Carolina:* 5th, 12th, and 17th. *Alabama:* 4th, 14th, and 16th. *Mississippi:* 7th, 8th, 10th to 16th. *Tennessee:* 2d to 5th, 8th, 10th, 12th, 15th, 19th, and 27th. *Kentucky:* 1st to 6th, 9th, 10th, 14th, and 15th. *Arkansas:* 3d, 9th, and 15th. *Indian Territory:* 3d, 4th, 18th, 19th, 20th, and 31st. *Minnesota:* 2d, 7th, 8th to 13th, 16th, 24th, 28th, and 31st. *Dakota:* 1st to 10th, 18th, 20th to 26th. *Montana:* 1st, 4th, 6th, 10th, 11th, 16th, 25th, 26th, and 27th. *New Mexico:* 6th, 15th, and 16th. *Utah:* 22d, 27th, and 28th. *Nevada:* 17th. *Idaho:* 6th, 18th, and 22d. *Oregon:* 5th and 18th.

Auroras.—Auroral displays were observed north of the 40th parallel

from Maine to Montana, on the 1st, 5th, 6th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, 26th, 28th, 29th, and 31st.

EFFICIENCY OF LIGHTNING CONDUCTORS.

"Direct evidence as to the efficiency of lightning conductors is afforded in a government report from Schleswig-Holstein, which is referred to in a recent work on the subject by Mr. Richard Anderson. Thunder-storms are said to be more numerous in Schleswig-Holstein than in any other part of Central or Northern Europe, and the danger from lightning is correspondingly increased. The attention of the government insurance office was called to the fact, that in 4 out of 552 cases of claims on account of damage from lightning, arising in eight years, conductors of approved design had been in use, and an expert, Dr. Holtz, of Greifswald, was appointed to inquire into the causes of failure. He found that in every case where a building provided with a conductor had been struck by lightning, the conductor was not in an efficient state. Sometimes the point of the rod was needlessly ornamented with gilding, while the underground connection with the earth, the very element of safety, was neglected. In the absence of a proper ground connection, the lightning-rod, instead of being a protection, may prove the means of attracting the discharge into the building. A measure for the periodical testing of conductors is suggested, for the detection of defective constructions, interruptions of conductivity by rusting or displacement, or of other faults that may arise from time to time."[1]

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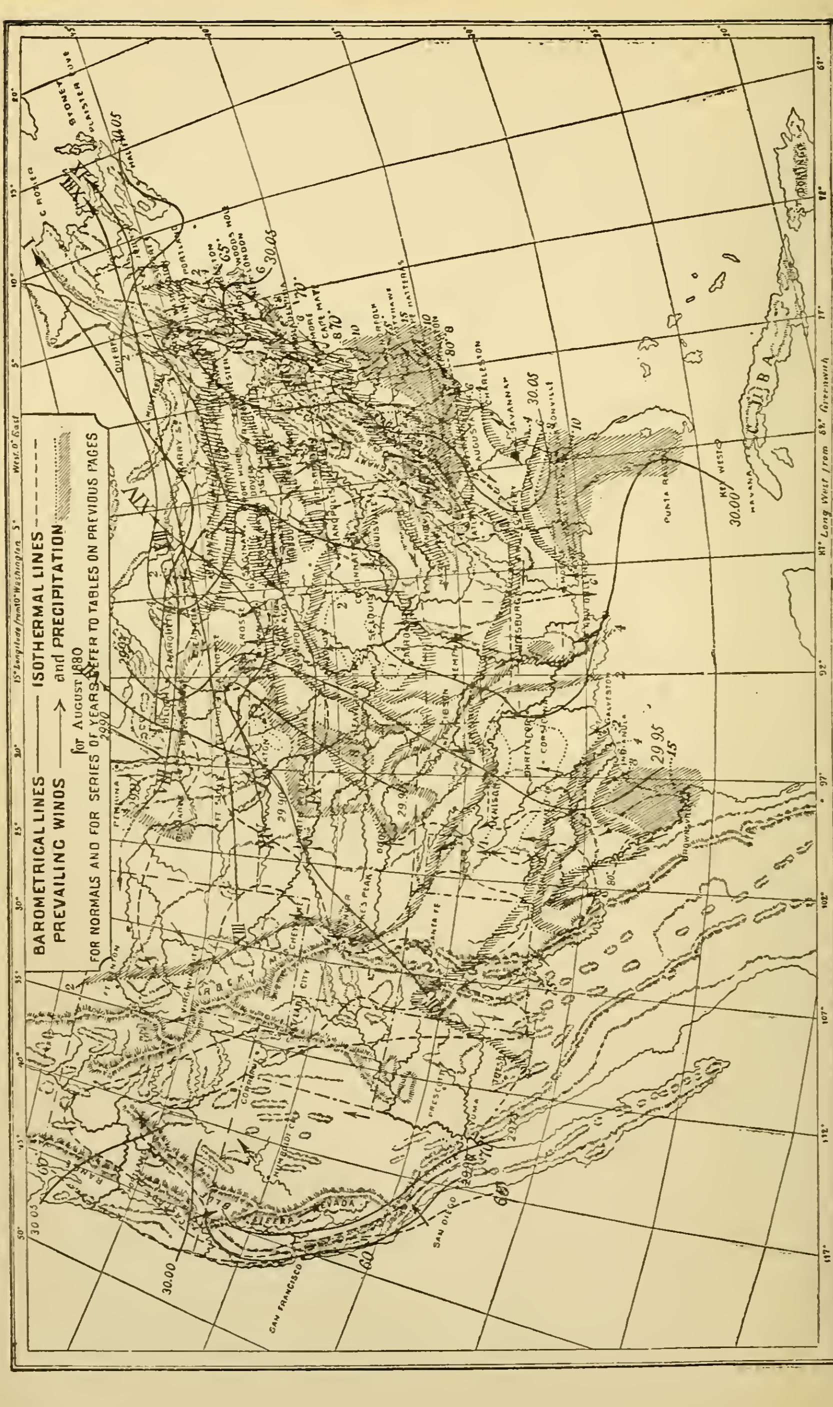
[1] Popular Science Monthly, July, 1880, page 421.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
for AUGUST 1880
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES

2. MONTHLY WEATHER REVIEW, AUGUST, 1880.

BAROMETRIC PRESSURE.

The general distribution of the atmospheric pressure, as reduced to sea-level, for the month of August, 1880, over the United States and Canada is shown by barometrical lines on the Chart. The region of highest pressure is on the Atlantic coast, and farther northward than usual, covering the coast from New Jersey to North Carolina instead of being confined to the South Atlantic States. The region of lowest pressures extends from Manitoba to Southern Texas. On the Pacific coast, the highest pressure is, as usual, in Oregon, while the lowest means are reported from the interior valleys.

Departures from the normal values for August.—The barometric means for August, 1880, when compared with the average for the past eight years, show marked and unusual departures. Over New England, the Middle Atlantic States, and the Lake region (except the southern half of Lake Michigan) the pressures range from .04 inch to .01 inch above the normal, being .07 above at Marquette, .09 at Albany, and .10 at Burlington. The Gulf States, the Upper Mississippi Valley, and the greater part of the Rocky Mountain region reported means slightly below the normal, the greatest deficiency being reported from Punta Rassa, .07 below the normal.

Barometric ranges.—The local barometric ranges, reduced to sea-level, have been very unusual and irregular, especially in those parts of the Gulf States over which the cyclones of August 12th and 29th passed, where the following ranges were reported: Punta Rassa, 0.65; Indianola and Galveston, 0.45; Cedar Keys, 0.80; Pensacola, 0.81; Mobile, 0.84; Laredo, 1.09; Brownsville, 1.79. Ranges exceeding 0.90 are reported from the Red River of the North Valley, from Burlington, Vt., and North Platte, Nebr. The smallest ranges in the country were: Santa Fé, 0.24; Campo, 0.32; and Key West, 0.33.

Areas of high barometer.—During the month of August, 1880, eight areas of high pressure prevailed within the limits of the Signal Service stations. Nos. II. and VIII. were slight encroachments of the area of high barometer from the Pacific ocean. The remaining areas were the usual outflows of cold air moving southeastward from the Saskatchewan region. Area No. III. was marked by the first frosts east of the Mississippi River.

Areas of low barometer.—During the month, sixteen areas of low pressure have occurred within the limits of the Signal Service stations,

only ten of which have been sufficiently definite to permit of charting. No storm has been charted entirely across the country. The marked meteorological feature of the month has been the advent of three violent cyclonic storms—a most unusual number. No. V. devastated the Texas coast, at the mouth of the Rio Grande River, during the 12th and 13th. In its passage over the Gulf of Mexico, the steamer San Salvador, long overdue, was probably lost. No. X., during the 18th, passed over Jamaica, where it caused the loss of several lives, and did immense damage to shipping, buildings, crops, and other property. No. XVI., the cyclone in which the steamer City of Vera Cruz was lost, moving eastward to the north of the Bahamas on the 28th, crossed northern Florida during the 29th and 30th. This storm strewed the Florida coast with wrecks, and did great damage to property and growing crops. As far as has been noted, the loss of life was confined to the crew and passengers of the steamer City of Vera Cruz.

TEMPERATURE OF THE AIR.

The mean temperatures for August, 1880, are shown by isotherms on the Chart. The average temperatures show a deficiency of temperature for the entire country, except Tennessee, the Ohio, Upper Mississippi, and Lower Missouri Valleys, from which sections slight excesses, not exceeding 1°, were reported. Deficiencies exceeding 1° are as follows: Pacific coast, about 2°; Plateau districts, from 2° to 3°; Saint Lawrence Valley, 2°; Upper Missouri Valley, 4°; and Rio Grande Valley, 6°.

Frost.—California: Lompoc, 18th; Campo, 30th and 31st, injuring vegetables. *Colorado:* Hermosa, 30th and 31st; Summit, frequent; Pike's Peak, 2d, 7th, and frequent after 16th. *Connecticut:* New London, 16th, light in low lands near. *Idaho:* Boise City, 25th and 26th, in low places. *Maine:* Bangor, 25th and 26th; Portland, 27th, in suburbs of city. *Massachusetts:* Rowe, 16th, Springfield, 16th and 29th; Westborough, 16th and 27th; Boston, 16th, light in suburbs. *Michigan:* Thornville, 3d, on low grounds. *New Hampshire:* Auburn and Contoocookville, 16th, on low grounds; Grafton, 12th and 26th; 16th, damaging corn in low places, "frost very general throughout State"; Mount Washington, 5th, 6th, 15th, frost feathers 3 to 6 inches long in exposed places; 10th to 23d. *New Jersey:* Freehold, 16th, 5 miles S.E. of station; Linden, 18th. *New York:* Ardenia, North Volney, and near Penn Yan, 16th, Palerno, 16th, light; Cooperstown, Port Jervis, and Nile, 16th, and 17th, injuring corn, buckwheat, and potatoes at latter place; Buffalo, 16th, on low grounds; Albany, 16th, on mountains near, damaging vegetables. *Nevada:* Carson City, 11th, 26th, 30th and 31st; Winnemucca, 31st.

PRECIPITATION.

The general distribution of rainfall for August, 1880, is shown on the Chart, as accurately as possible from about 500 reports. Departures exceeding one inch from the normal precipitation are as follows: Missouri Valley about 1.20 excess; Lower Lake region, 1.70 excess; Florida peninsula, 4.03 excess; the Gulf States about 1.25 deficiency; Saint Lawrence Valley about 1.25 deficiency. In Oregon and the southern part of California slight deficiencies are reported, while in Northern and Central California no rain has fallen. The great excess in the Florida peninsula resulted from the cyclone of August 29th; most unusual number of heavy rains occurred during the month.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 9 to 17; Middle Atlantic States, 9 to 16; South Atlantic States, 10 to 19; Eastern Gulf States, 12 to 15; Western Gulf States, 5 to 18; Ohio Valley and Tennessee, 7 to 20; Lower Lake region, 11 to 17; Upper Lake region, 12 to 16; Upper Mississippi Valley, 7 to 14; Missouri Valley, 9 to 13; Red River of the North Valley, 9 to 15; Texas, 1 to 16; Rocky Mountains, 7 to 22; Middle Plateau, 1 to 4; California, 0 to 2; Oregon, 4 to 5.

Cloudy days.—The number varies in New England from 2 to 11; Middle Atlantic States, 7 to 19; South Atlantic States, 4 to 18; Eastern Gulf States, 4 to 11; Western Gulf States, 2 to 9; Ohio Valley and Tennessee, 4 to 11; Lower Lake region; 6 to 13; Upper Lake region, 6 to 13; Upper Mississippi Valley, 1 to 10; Missouri Valley, 7 to 9; Red River of the North Valley, 8 to 9; Texas, 2 to 10; Rocky Mountains, 2 to 8; Middle Plateau, 0 to 4; California, 0 to 5; Oregon, 1 to 9.

Hail.—*Arizona:* Camp Verde, 6th. *Colorado:* Summit, 3d, 8th, 10th, 12th, 15th; Pike's Peak, 1st to 3d, 7th to 8th, 14th, and 25th to 28th. *Indiana:* New Corydon, 17th; Logansport, 2d. *Iowa:* Guttenburg, 16th. *Maine:* Bangor, 10th. *Michigan:* Coldwater, 17th; Lansing, 18th. *Minnesota:* Duluth, 12th. *Nebraska:* De Soto, 27th and 31st. *New Hampshire:* Mount Washington, 12th. *New Jersey:* South Orange, 11th; Sommerville, 25th, one-third of an inch in diameter. *North Carolina:* Highlands, 17th. *Ohio:* Bethel, Jacksonburg, and Norwalk, 11th. *Pennsylvania:* Hulmeville, 25th. *Wyoming:* Cheyenne, 26.

Snow.—*Colorado:* Summit, 1st to 3d, one inch. *Nevada:* Winnemucca, 29th, on neighboring mountains. *Utah:* Salt Lake City, in the mountains near, on the 30th. *Washington Territory:* Pomeroy, 29th, on hill near town.

Droughts.—Waveland, Ind., to August 23d, very severe. Creswell, Kans., severe to 18th. Auburn, N. H., 31st, severe, "vegetation suffering badly, streams drying up." Winnemucca, Nev., 17th, the "Sink" of the Humboldt completely dry; said to be the first time within the

memory of man. Des Moines, 15th, "crops sufferings." Wellington, Kans., 27th. Carrollton, Ill., and Independence, Mo., to August 20th, corn and other crops severely damaged. The Missouri weather review states that the entire State suffered from drought till the 20th.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, from 63 to 83; Middle Atlantic States, 63 to 89; South Atlantic States, 71 to 82; Eastern Gulf States, 69 to 78; Western Gulf States, 61 to 79; Ohio Valley and Tennessee, 63 to 78; Lower Lake region, 65 to 77; Upper Lake region, 71 to 78; Upper Mississippi Valley, 60 to 70; Missouri Valley, 60 to 65; Red River of the North Valley, 73 to 76; Texas, 60 to 79; Middle Plateau, 16 to 25; California, 32 to 82; Oregon, 44 to 69. *High stations* report the following averages not corrected for altitude: Pike's Peak, 73.6; Mount Washington, 80.3; Virginia City, 36.9; Denver, 47.2; Santa Fé, 49.2.

WINDS.

The *prevailing directions of the wind* during August, 1880, are shown by arrows, flying with the wind on the Chart. From the Mississippi Valley westward to the Pacific Ocean the predominating winds have been southerly, except in the northern half of the Pacific coast region, where they were northerly. In New England, the Lower Lake region, the Middle Atlantic States, and the Ohio Valley, they have been south-westerly, except at a few scattered stations. In the South Atlantic States and Tennessee they were variable, with the easterly points predominating. At most stations in the Upper Lake region the prevailing winds were northerly. On Mount Washington the prevailing wind was N.W. and the maximum velocity N.W. 60, on the 2d; maximum velocities of 50 miles or more occurred as follows: 10th, 20th, 23d, 25th, 28th, and 29th, N.W. 50; 24th, W. 52. On Pike's Peak the total movement was 8,445, prevailing direction S.W., maximum velocity 64 S.W. Maximum velocities exceeding 50 miles were reported as follows: Indianola, 64 N.E. 13th; Cedar Keys, 64 N.E. on the 30th; Yankton, 56 S.W. on the 16th and Kittyhawk on the 12th; Punta Rassa, 56 S.W. on the 29th, and 56 (72 miles for 5 minutes) S. on the 30th; Brownsville, Tex., 48 miles on the 12th, when anemometer was blown down; exact maximum unknown.

Local storms.—West Randolph, Vt., on the 12th, violent hail-storm, with wind and heavy rain, width of path, 1½ miles; stones as large as butternuts; over 2,000 panes of glass destroyed. Versailles, Ohio, on the 12th, very destructive hail-storm, seriously injuring tobacco and other crops. 18th, violent tornado, 14 miles S.W. of Fargo, Dak.; track

two miles wide, extending across the southern part of Cass County; one man killed, three severely injured, many houses blown down. August 24th, violent local storm one mile wide and seven miles long, swept over Great Neck, Little Neck, and Creedmoor, Long Island, damaging many buildings and injuring crops. In addition to the damage done by the cyclone at and near Brownsville, 12th and 13th, the following are reported: San Diego, Tex., many buildings unroofed; at Collins and Banquette, railway bridges damaged; Goliad, Tex., great damage to buildings. Fort Mojave, Ariz., 22d, most violent storm, barracks blown down, four men killed and five wounded.

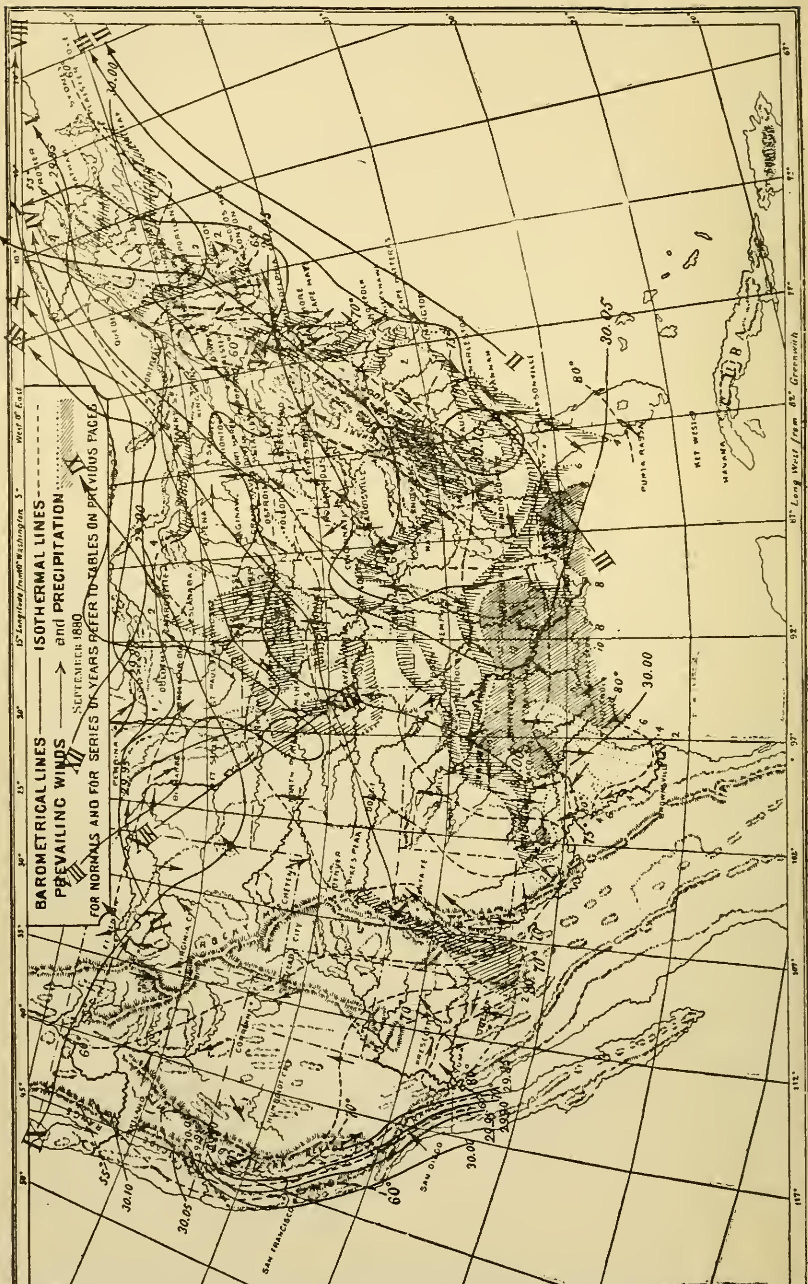
Water-spouts.—Near Hat Creek, Wyo., on the 29th, 2 P.M., moved from N. to S. for ten minutes in a zigzag course. Red Cañon, Dak., during night of 28th, destroying telegraph line for eleven miles.

Sand-storms.—Tucson, Ariz., 3d; Florence, Ariz., 9th; Winnemucca, Nev., 4th, 10th, 23d, 28th.

ATMOSPHERIC ELECTRICITY.

Thunder-storms have been reported in too great numbers to permit their enumeration in detail. They have occurred with greatest frequency as follows: *Georgia:* 23d to 25th. *Illinois:* on 23d, 27th, and 31st. *Indiana:* 2d, 10th, 20th, 28th to 30th. *Iowa:* 1st, 16th, 17th, 19th, 23d, 26th, and 27th. *Kansas:* 1st, 2d, 4th, 20th, 24th, 25th, 27th to 31st. *Louisiana:* 8th and 13th. *Maine:* 21st. *Maryland:* 25th and 29th. *Massachusetts:* 12th, 21st, 25th, and 29th. *Michigan:* 1st, 9th, 10th, 24th, and 27th. *New York:* 2d, 10th, 24th, 25th, 27th to 29th. *North Carolina:* 11th and 12th. *Ohio:* 2d, 10th, 11th, 14th, 17th, 19th, 20th, 25th, 29th to 31st. *New Jersey:* 2d, 11th, 12th, 24th, 25th, 28th, and 31st. *Nebraska:* 16th, 23d, 24th, and 26th. *Missouri:* 1st, 16th, and 31st. *Texas:* 16th and 17th. *Pennsylvania:* 2d, 11th, 19th, 24th, 25th, 28th, and 29th. *Tennessee:* 21st, 23d, and 27th. *Vermont:* 2d, 9th, 20th, 24th, and 28th. *Virginia:* 3d and 10th. *West Virginia:* 28th and 29th. *Wisconsin:* 1st, 26th, 27th, and 31st. On the Pacific coast, a thunder-storm occurred at San Diego, violent, on the 17th, at Portland, Oreg., 17th, and near Dayton on the 2d; lightning was observed at Red Bluff, Cal., on the 28th.

Auroras.—Auroras during August, 1880, have been frequent, and during the 12th and 13th were of remarkable brilliancy, as well as widespread.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
SEPTEMBER 1880
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES

3. MONTHLY WEATHER REVIEW, SEPTEMBER, 1880.

BAROMETRIC PRESSURE.

The general distribution of the atmospheric pressure, as reduced to sea level, for the month of September, 1880, over the United States and Canada is shown by isobaric lines on the Chart. At a few out-lying stations the means are given in figures indicating English inches. The regions of highest pressures, as usual, include the South Atlantic States and the North Pacific coast region. The regions of lowest pressures are the valleys of the Red River of the North and of California.

Departures from normal values for September.—The barometric means for September, 1880, when compared with the average for past years, show but slight and unimportant departures. The New England coast reports slight deficiencies, amounting at Boston and Portland to 0.05 inch. In the northwest, Saint Vincent—where the pressure was 0.11 below—is the only station reporting any great departure from the normal. In the South Atlantic States the following excesses are reported: Savannah and Jacksonville 0.05, and Augusta 0.07, above the normal.

Barometric ranges.—The local barometric ranges, reduced to sea-level, have been quite irregular but not excessive. The ranges along the Gulf coast have been from 0.20 at Key West to 0.47 at Mobile and New Orleans. In the Atlantic States the range steadily increased northward from 0.41 at Jacksonville to Central New England, where the following ranges occurred: Boston, 0.84, Springfield, 0.86; and Albany, 0.87. In the Upper Lake region the ranges were from 0.65 at Detroit to 0.86 at Marquette. In the Northwest the ranges were decidedly irregular, being 0.78 at Bismarck, 0.88 at Breckenridge, and 0.84 (the largest in the country) at Saint Vincent. On the Pacific coast the following ranges were reported: 0.24 at San Diego, 0.29 at San Francisco, and 0.55 at Portland.

Areas of high barometer.—During September, 1880, six areas of high pressure prevailed. No. I. was a storm of marked severity in the Lake region, where, during its prevalence, a number of disasters to shipping occurred. No. II. is particularly noticeable as having originated on the Pacific coast, and as having moved eastward across the Rocky Mountains. The only extensive and damaging frosts occurred in connection with area No. VI., during September 30th and October 1st.

No. VI.—On the 28th, the barometer rose in the Upper Missouri Valley; Fort Buford barometer at midnight 0.31 above the normal.

Moving southeastward on the afternoon of the 29th, the ridge of highest pressure extended from Texas northward to the Red River of the North Valley. On the morning of the 30th, the area covered the Lower Mississippi Valley. At midnight, the area of highest pressure was over the Middle Atlantic States; Baltimore and Cape Henry barometers 0.25 above the normal. The passage of this area was marked by the minimum temperatures for the month for the entire country east of the Mississippi River, excepting New England and North Carolina.

Areas of low pressure.—Thirteen such areas pertaining to the month of September, 1880, are described, and the course of eleven centres are shown on the Chart. The tracks of areas VI. and VII. could not be indicated with sufficient accuracy and are omitted. Only one area, No. IX., originating over the Pacific Ocean, crossed the Rocky Mountains. Area No. III. was a storm of unusual severity, particularly along the New England. the Virginia, and North Carolina coasts. Areas No. VIII. and XII. were severe storms which passed through the Lake region.

No. I. was the continuation of the Florida cyclone described in the August review. Central in Mississippi, the morning of the 1st it moved northward with increasing pressure and was in Illinois the morning of the 2d, thence, by a northeastward track, passed down the valley of the Saint Lawrence during the 3d and 4th. No signals were displayed during the passage of this area. The only cases of brisk winds reported were: S.E. 32 at Delaware Breakwater, and S. 25 at Cleveland.

TEMPERATURE OF THE AIR.

The mean temperatures for September, 1880, are shown by isotherms on the Chart. East of the Rocky Mountains an excess of temperature has prevailed in New England, Canada, Lower Lake region, and Middle States. In the Missouri and Upper Mississippi Valleys and Upper Lake region the mean temperature was normal. Elsewhere deficiencies were reported—the greatest in Texas. Westward of the Rocky Mountains the temperature has been normal, or above, to the north of parallel 42°, while to the south, deficiencies have been reported. That at San Diego, 3°.06, being the greatest departure from the normal in the country.

The following extracts relating to the temperature of the month are noted as of interest:

Riley, Ill., mean temperature 2° below average of 19 years; Gardiner, Me., temperature 2°.1 above mean of 44 years; Westborough, Mass., mean temperature 7° above that of August; Linden, N. J., no frost during month; Newark, N. J., temperature 5°.9 above mean of 37 years; Philadelphia, temperature 6°.9 above mean of 91 years; Baltimore, 5th, two fatal sunstrokes.

PRECIPITATION.

The general distribution of rain-fall for September, 1880, is shown on the Chart as accurately as possible, from about 500 reports. The rain-fall has been normal in New England, the Ohio, Lower Missouri, Upper Mississippi, and St. Lawrence Valleys. Elsewhere deficiencies have occurred, except in the Gulf States, from which districts excesses ranging from 1.36 in the eastern to 4.24 inches in the western half are reported. In Central Texas the rain-fall was unusually large, causing local floods, which are elsewhere noticed. The rain-fall was greatly deficient (over 3 inches) in Florida and the South Atlantic States. Less important deficiencies are noted in the Lake region, Upper Mississippi Valley, Minnesota, and on the entire Pacific coast.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 6 to 17; Middle Atlantic States, 5 to 11; South Atlantic States, 5 to 13; Eastern Gulf States, 5 to 19; Western Gulf States, 11 to 17; Ohio Valley and Tennessee, 10 to 17; Lower Lake region, 8 to 16; Upper Lake region, 11 to 18; Upper Mississippi Valley, 5 to 10; Missouri Valley, 6 to 10; Red River of the North Valley, 7 to 13; Texas, 3 to 17; Rocky Mountains, 2 to 11; Middle Plateau, 0 to 5; California, 0; Oregon, 3 to 8.

Cloudy days.—The number varies in New England from 4 to 14; Middle Atlantic States, 5 to 10; South Atlantic States, 6 to 12; Eastern Gulf States, 2 to 13; Western Gulf States, 9 to 13; Ohio Valley and Tennessee, 6 to 16; Lower Lake region, 7 to 10; Upper Lake region, 6 to 13; Upper Mississippi Valley, 4 to 6; Missouri Valley, 5 to 7; Red River of the North Valley, 5 to 8; Texas, 0 to 13; Rocky Mountains, 0 to 6; Middle Plateau, 0 to 2; California, 0 to 9; Oregon, 2 to 6.

Hail.—Colorado: Pike's Peak, 1st, 6th, 8th to 10th, 18th, 21st. Summit, frequent. *Iowa:* Davenport, 19th; some stones over one-half inch in diameter, half ice, very irregular shape, with numerous conical projections; some had cavities in centre; Mt. Vernon, 15th; Ames and Yates Centre, 25th. *Kansas:* Leavenworth, 25th. *Michigan:* Kalamazoo, 29th; Marquette, 28th. *New York:* Waterburg, 6th, 28th; Dundee, Buffalo, Oswego, and Rochester, 29th; North Volney, 30th. *Ohio:* Cleveland, 28th, 29th; very large stones; Margaretta, 29th. *Minnesota:* At Euclid, 24th; very large hail over a belt of country two miles wide; one stone weighed 12 ounces, and the diameter of the longer axis of another was 4 inches; men found it necessary to protect their heads. *Nebraska:* North Platte, 17th.

Snow.—California: Visalia, 24th, on mountains east of town. *Colorado:* Denver, 25th; Pike's Peak, 2d, 9th, 20th, 21st, 25th, 26th; Colorado Springs, 26th; Fort Garland (7th, Baldy and Sierra Blanca covered with snow), 26th. *New Hampshire:* Mount Washington, 10th.

New York: Rochester, 14th. *Michigan:* Fort Wayne, 29th. *Vermont:* Mount Mansfield, 23d. *Wyoming:* Lookout Station, 25th.

Droughts.—The droughts reported from New England undoubtedly result from the great deficiency in rain-fall of nearly 6.00 inches, from March 1st to June 30th of this year. The rainfall from July 1st to October 1st has been slightly above the normal in that section of the country. Bangor, Me., to 9th; great suffering in farming districts; streams drying up; stock driven long distances for water; many mills stopped. Charlotte, Vt., severe to the 13th. Windsor, Vt., severe at beginning of month up to 9th. Woodstock, Vt., 28th, drought of July and August still prevails; many wells and streams dry; farmers compelled in early part of month to haul water for stock. Westborough, Mass., month warm and dry. Auburn, N. H., drought severe in early part of month. Fort Madison, Iowa, 30th, water scarce; some wells dry. Sandy Springs, Md., 30th, slight drought.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, from 71 to 81; Middle Atlantic States, 66 to 87; South Atlantic States, 69 to 88; Eastern Gulf States, 71 to 80; Western Gulf States, 70 to 81; Ohio Valley and Tennessee, 62 to 77; Lower Lake region, 65 to 73; Upper Lake region, 65 to 75; Upper Mississippi Valley, 62 to 71; Missouri Valley, 60 to 67; Red River of the North Valley, 70 to 76; Texas, 67 to 81; Middle Plateau, 19 to 39; California, 37 to 79; Oregon, 64 to 78. High stations report the following percentages not corrected for altitude: Mount Washington, 86.6; Denver, 43.9; Virginia City, 31.0; Cheyenne, 38.6.

WINDS.

The prevailing directions of the wind during September, 1880, are shown by arrows, flying with the wind, on Chart. The prevailing direction in New England, the Lake region, the Ohio and Upper Mississippi Valleys was southeasterly; in Florida, Tennessee, the South Atlantic, and Eastern Gulf States, northeasterly; in the Western Gulf States, including all of Texas, southeasterly; the Upper Missouri and Red River of the North Valley, northwesterly; the Lower Missouri Valley and the Eastern Rocky Mountain slope, southerly. On the Pacific coast it was northwesterly, except south at Sacramento and southwest at Los Angeles. In the Middle Atlantic States the winds were mostly from the northwest to southwest. In the Plateau districts they were variable. On Mount Washington, the prevailing direction was N.W., and maximum velocity was S. 76 miles per hour on the 28th. Other maximum velocities of 50 miles or more occurred as follows: 10th, N.E. 60; 15th,

N.E. 70; 21st, N.W. 70; 22d, N.W. 60; 27th, N.W. 57. The prevailing direction on Pike's Peak was S.W.; the total monthly movement was 9,824 miles and maximum velocity 50 miles W., 4th. A maximum velocity of 50 miles N.E. was reported from Cape Henry on the 9th.

Local storm.—On Friday, the 3d, a tornado passed through the south part of Riley, Ill. It came from the southwest and moved to the northeast in a path about 200 feet wide. An observer says: It turned a tree, 2 feet in diameter, up by the roots, and twisted off two others of 2 feet diameter, about 12 feet from the ground and carried the sundered parts eight or ten rods, and scattered them in pieces over a large surface. It broke off a sound hard maple of thirty years' growth, over a foot in diameter, 10 feet from the ground, and took off several feet of the tops of stacks of oats and scattered the bundles. It all occurred within five minutes, and in the mean time water came down in torrents with a whirling motion. There was considerable damage done in Harmony and elsewhere south of Riley by the same storm, but no houses blown down.

Water-spouts.—Key West, Florida, 16th, 3 P.M., about six miles distant. Buffalo, 29th, 4 water-spouts reported to have been seen on Lake Erie, 4 miles from this city, moving from S.W. to N.E. They were said to be cylindrical rather than conical.

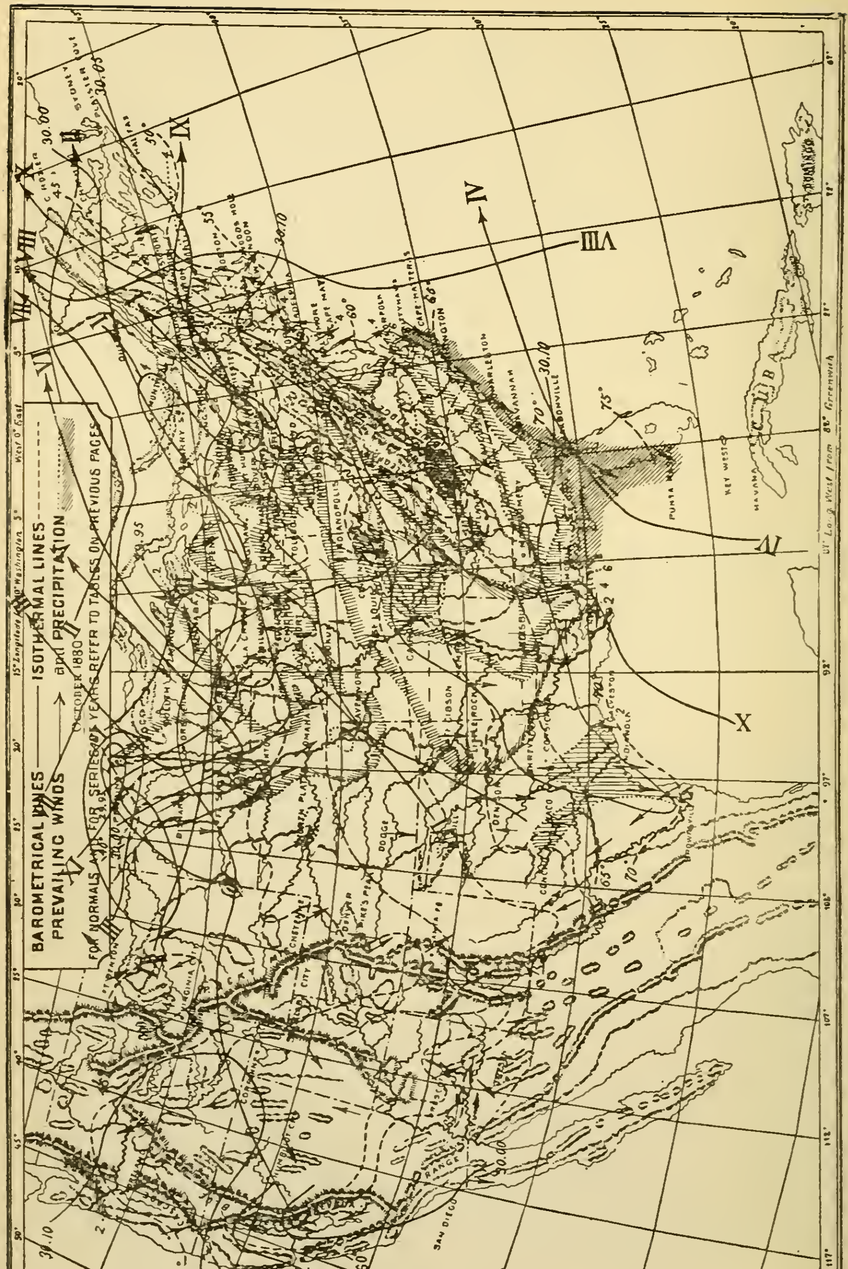
Sand-storms.—Umatilla, Oregon, 22d; Burkes, Ariz., 9th and 12th.

ATMOSPHERIC ELECTRICITY.

Thunder-storms have occurred with the greatest frequency as follows *Illinois:* 3d, 18th, and 19th. *Indiana:* 3d, 5th, 6th, 15th, 18th, 25th. *Iowa:* 3d, 6th, 19th, 25th. *Kansas:* 3d, 18th, 25th. *Michigan:* 1st, 19th. *Nebraska:* 6th, 18th, 25th. *Missouri:* 19th. *New York:* 4th. *Ohio:* 4th, 28th. *Virginia:* 5th and 6th. *Tennessee:* 4th, 5th. *Texas:* 3d, 4th, 6th, 7th, 12th, 22d to 26th. In other States they have occurred with comparative infrequency. At Santa Barbara, Cal., a thunder-storm occurred the 7th.

Atmospheric electricity interfering with telegraph lines.—*New Mexico:* Silver City, on the 9th, 10th, 21st; Santa Fé, 6th, 26th; Socorro, 12th, 16th, 20th, 26th, 28th, 29th; La Mesilla, 10th, 20th.

Auroras were nightly observed, from the 27th to the 30th, inclusive, over a wide extent of country, from Maine westward to Dakota, and as far south as latitude 40°. They were visible as far west as Fort Buford on the 27th, 28th, 29th, and at Bismarck on the 30th. To the eastward they were observed as far as Grafton, N. H., on 27th; Bangor, 29th; and Gardiner, Me., 28th to 30th.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
OCTOBER 1880
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES

4. MONTHLY WEATHER REVIEW, OCTOBER, 1880.

BAROMETRIC PRESSURE.

The general distribution of barometric pressure as exhibited on the Chart differs slightly from the mean pressure as determined from the observations for many years. The greatest variation from the mean occurs on the North Pacific coast, where the pressure is seven hundredths above the normal at Portland. The pressure has increased from three to six hundredths in all districts east of the Mississippi, and the area of mean high barometer which covered the Southern States in September has increased and moved north over the Middle Atlantic States and New England.

Barometric ranges.—The barometric range for the several stations increases with the latitude and is unusually great in the Upper Mississippi Valley and Upper Lake region, located near the track of the centre of the storm which passed over these regions on the 16th and 17th. The range increases on the Atlantic coast from 0.30 at Key West to 1.22 at Portland, Me., and in the Mississippi Valley from 0.68 at New Orleans to 1.68 at La Crosse, this being the greatest range reported. In the Lake region, the range varies from 0.89 at Rochester to 1.51 at Duluth. On the Pacific coast the range increases with the latitude, but is much less than at corresponding latitudes on the Atlantic coast.

Areas of high barometer.—Nine areas of high barometer have appeared within the limits of the Signal Service stations during the month of October, four of which—Nos. II., V., VII., and IX.—were traced from the North Pacific to the Atlantic coast. No VI. apparently developed in the Southwest, and followed the general direction of the storm of the 16th and 17th, being preceded by the most severe norther of the month on the Texas coast.

Areas of low barometer.—On the Chart will be found the tracks of centres of the areas of low pressure, which have been traced from the tri-daily weather maps of the month. The mean latitude of these tracks is several degrees to the north of the mean latitude of low areas for corresponding month of previous years. Nos. IV., VIII., and XI. were tropical storms, which developed south of latitude 25°, and No. VI., the most marked depression of the month, apparently developed in the Southwest, probably in Northern Texas. No. XII. is the only depression that crossed the Rocky Mountains, and this disappeared before reaching the Lake region.

TEMPERATURE OF THE AIR.

The mean temperature of the air during October, 1880, is shown by the isothermal lines on the Chart. In the Southern States east of the Mississippi River, and in the Middle States, the temperature has been near the normal of many years. In all the other districts east of the Rocky Mountains it has averaged from one to five degrees below the normal, the greatest departures being in Western Texas, and thence northward over Kansas and Colorado. On the Pacific slope, the temperature corresponds with the normal, except at San Diego, where it is one degree below, and in the southern Plateau district, where it has averaged over two degrees below. The temperature is slightly above the normal in the lower Saint Lawrence Valley and Gulf of Saint Lawrence.

PRECIPITATION.

The general distribution of rain-fall for October, 1880, is shown on the Chart, as accurately as possible, from about five hundred reports. East of the Mississippi River, except in the Upper Mississippi Valley, Upper Lake region, and Middle Atlantic States, where there were slight deficiencies, there were excesses of rain-fall, ranging from 3.36 inches in the Florida peninsula and 2.40 inches in the South Atlantic States to 0.17 in New England. West of the Mississippi, except in Minnesota and the Lower Missouri Valley, where slight excesses occurred, the rain-fall was below the average, the greatest deficiency, 1.47 inch, occurring in the North Pacific coast region.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 7 to 16; Middle Atlantic States, 5 to 13; South Atlantic States, 7 to 17; Eastern Gulf States, 10 to 14; Western Gulf States, 4 to 10; Ohio Valley and Tennessee, 10 to 16; Lower Lake region, 14 to 22; Upper Lake region, 7 to 20; Upper Mississippi Valley, 5 to 10; Lower Missouri Valley, 5 to 7; Red River of the North Valley, 9 to 11; Rio Grande Valley, 3 to 8; Texas, 3 to 7; Rocky Mountains, 5 to 17; Western Plateau, 0 to 5; California, 0 to 3; Oregon, 3 to 10; Washington Territory, 7 to 9.

Cloudy days.—The number varies in New England from 5 to 14; Middle Atlantic States, 6 to 10; South Atlantic States, 8 to 16; Eastern Gulf States, 6 to 16; Western Gulf States, 3 to 10; Ohio Valley and Tennessee, 8 to 13; Lower Lake region, 10 to 13; Upper Lake region, 8 to 16; Upper Mississippi Valley, 7 to 12; Lower Missouri Valley, 5 to 11; Red River of the North Valley, 12 to 14; Rio Grande Valley, 4 to 7; Texas, 1 to 9; Rocky Mountains, 4 to 9; Western plateau, 2 to 5; California, 1 to 3.

Hail.—New York: Madison Barracks, 6th; Buffalo; 17th, 18th.

Pennsylvania: Catawissa, Fallsington, Philadelphia, and West Chester, 28th; Green Castle, 26th. *New Jersey:* Freehold and Princeton, 28th. *Illinois:* Chicago, 1st, 2d, 25th; Morrison and Sterling, 2d. *Iowa:* Dubuque, 14th, 16th; Clinton, 3d; Cresco, 15th; Mount Vernon, 2d. Des Moines, 15th, severest storm experienced since opening station; great damage to windows; stones varied in size from hickory nuts to walnuts; width of track, one-quarter mile; direction from southwest to northeast. *Kansas:* Holton, 2d. *Michigan:* Lansing, 2d, 25th; Marquette, 16th. *Minnesota:* Saint Vincent, 10th; New Ulm, 15th; Duluth, 28th. *Wisconsin:* Milwaukee, 25th. *Dakota:* Fort Bennett, 15th, 16th. *Texas:* San Antonio, 27th; Pilot Point, 15th. *New Mexico:* Santa Fé, 12th. *Oregon:* Albany, 10th. *Washington Territory:* Pomeroy, 14th.

Snow.—New Hampshire: 19th, 24th, 26th; on summit of Mount Washington, 1st, 2d, 5th, 6th, 7th, 8th, 12th, 13th, 18th to 23d, 25th to 31st. *Vermont:* 19th, 20th, 23d, 25th, 28th. *Massachusetts:* 19th, 20th, 24th. *New York:* 17th, 18th, 19th, 20th, 23d, 24th, 27th, 28th. *New Jersey:* 19th, 28th. *Pennsylvania:* 19th, 24th, 28th. *Maryland:* 19th, 22d, and 23d in mountains. *West Virginia:* 19th, 23d. *Kentucky:* 19th. *Ohio:* 17th, 19th, 20th, 23d, 24th. *Michigan:* 16th to 24th, 26th, 27th. *Indiana:* 15th, 17th to 19th. *Illinois:* 16th, 17th, 19th to 23d. *Missouri:* 16th. *Wisconsin:* 16th, 17th to 19th, 23d. *Iowa:* 15th to 19th, 23d. *Kansas:* 15th, 16th. *Nebraska:* 14th to 18th, 21st. *Minnesota:* 15th to 21st, 23d, 30th. *Dakota:* 9th, 15th to 18th, 26th. *Colorado:* 9th to 13th, 15th, 26th, 30th. On summit of Pike's Peak, 9th, 11th, 12th, 13th, 18th to 24th, 31st. *New Mexico:* 10th, 11th. *Nevada:* 8th, 10th, 11th, 12th. *Utah:* 8th, 9th, 10th, 14th. *Wyoming:* 9th, 10th, 14th to 18th, 29th. *Idaho:* 14th. *Montana:* 8th, 9th, 14th, 15th, 28th.

Droughts.—Fort Madison, Iowa, 30th, water very scarce; pastures drying up. Yates Center, Kans., 31st, streams and ponds lower than for past six years. Emmittsburg, Md., 30th, month very dry. Sandy Springs, Md., 31st, great scarcity of water; streams unusually low. Contoocookville, N. H., 1st to 30th, quite severe. Palermo, N. Y., 18th, very dry; wells and streams low. Greencastle, Pa., last half of month streams very low; wells and springs nearly dry; boats on Delaware and Hudson Canal stopped running for want of water. Woodstock, Vt., throughout month springs and wells remarkably low. Wytheville, Va., 29th, drought has been very severe since the 1st; cisterns and wells generally exhausted and streams very low.

Snow from a cloudless sky.—Springfield, Ill., 18th.

Snow on ground at end of month.—Virginia City, Mont., 1.50 inches; Pike's Peak, 2 feet 2 inches; Breckenridge, Minn., trace; Mount Washington, 4.00 inches.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, 66 to 80. Middle Atlantic States, 61 to 86 South Atlantic States, 62 to 80. Eastern Gulf States, 68 to 77. Western Gulf States, 70 to 76. Ohio Valley and Tennessee, 63 to 79. Lower Lake region, 67 to 70. Upper Lake region, 66 to 76. Upper Mississippi Valley, 58 to 65. Lower Missouri Valley, 62 to 64. Red River of the North Valley, 70 to 77. Rio Grande Valley, 63 to 71. Texas, 61 to 71. Western Plateau, 30 to 45. California, 37 to 71. Oregon, 54 to 82. *High stations* report the following percentages not corrected for altitude: Mount Washington, 80.7; Pike's Peak, 67.3; Denver, 55.9; Cheyenne, 45.0; Virginia City, 48.7; Santa Fé, 48.0.

WINDS.

The arrows on the Chart indicate the prevailing direction of the wind at the several stations during the month of October. The prevailing direction was north to east in the South Atlantic and Gulf States, in the southern portion of the area of mean high barometer for the month, and south to west in the Lake region, Ohio Valley, northwest and interior of Texas, the Middle States, and New England. Northerly winds prevailed on the Pacific coast as far south as Sacramento, and southeast to southwest winds in the southern portion of California. At stations in the Rocky Mountain region the prevailing direction was generally from the higher to lower altitudes. Pike's Peak, prevailing direction, northwest; highest velocity, 72 miles, west on 13th. Mount Washington, prevailing direction, northwest; highest velocity, 84 miles, northwest on the 24th and 31st.

Local Storms.—Under this head no storms of decided severity were reported during the month except in connection with the passage of low area No. VI. during the 15th, 16th, and 17th, which are herewith appended from the reports of various stations and other sources. Morrison, Ill., 16th, violent storm, hundreds of trees prostrated, and considerable damage to fences and out-buildings. Riley, Ill., 16th, great damage to trees, fences, corn-fields, and a "wholesale destruction of windmills;" heaviest storm ever experienced here; estimated velocity of wind, 70 miles per hour. Rockford, Ill., 16th, severe gale from the southwest, causing considerable damage. Elmira, Ill., 16th, violent southwest gale nearly all day. Springfield, Ill., 16th, considerable damage to trees, fences, and out-buildings. Chicago, 16th, violent southwest gale with sleet from 5.15 to 9.30 P.M., buildings blown down, and much damage to shipping; 17th, wind continued high all day. Independence, Iowa, 16th, snow accompanied by a violent westerly gale

from 1 to 11 P.M. Guttenberg, Iowa, 15th, severe thunder-storm, creeks in vicinity rose 11 feet above low-water mark; 16th, hurricane from west, accompanied by sleet. Logan, Iowa, 16th, violent westerly gale, worst storm for twenty years. Mount Vernon, Iowa, violent westerly gale all day. Nora Springs, Iowa, 16th, lowest barometer ever recorded, storm of great severity, all railroad communication westward suspended. Muscatine, Iowa, 16th, very heavy west gale. Cresco, Iowa, 16th, heavy westerly storm, lowest barometer for the year. Vail, Iowa, 16th, storm of unusual severity; snow-drifts, from 3 to 5 feet deep. Mitchellville, Iowa 15th, about 4 P.M. a tornado was noticed in the west coming rapidly in direction of town, accompanied by a deep, heavy, rumbling sound. The cloud, funnel-shaped and twisting with great rapidity, was accompanied by a heavy westerly gale, and sudden darkness overshadowed everything as it approached the western edge of the village, where it lifted from the earth and passed harmlessly to the northeast, when it again seemed to descend. Dubuque, Iowa, 16th, violent southwest wind, considerable damage to trees, fences, and out-buildings. Keokuk, Iowa, 15th, southwest 48 miles, considerable damage to property; 16th, west, 40 miles. Davenport, Iowa, 16th, great damage to fences, trees, and buildings, and navigation suspended. Topeka, Kans., 15th, southwest, 54 miles, much damage to property. Dodge City, Kans., 14th and 15th, north, 56 miles. Grand Rapids, Mich., 16th, 17th, violent southwest gale. Escanaba, 16th, much damage to shipping and other property. Port Huron, 16th, severe wind-storm, lasting thirty-six hours, much damage to shipping and other property. Port Huron, 16th, severe wind-storm lasting thirty-six hours, much damage to shipping. Grand Haven, 16th, southwest 48 miles, worst day ever seen at this station. Detroit, 17th, heavy southwest wind nearly all day. Genoa, Nebr., 15th, violent wind-storm from the north, severest for many years. De Soto, Neb., 16th, heavy northwest gale. North Platte, 16th, violent gale from northwest, 54 miles per hour: Wooster, Ohio, 17th, violent southwest wind nearly all day. Flemington, W. Va., 16th to 18th, very violent westerly winds. Ashland, Wis., 17th, heavy northeast gale, much damage to docks, warehouses, and shipping. Bloomfield, Wis., 16th, violent southwest gale, much damage to fences and buildings. Milwaukee, 16th, southwest 60 miles, much damage to buildings, and telegraphic communication interrupted. Madison, Wis., 16th, west, 44 miles, much damage to property. Breckenridge, northwest, 56 miles, 1.30 P.M. Duluth, 16th, northeast and northwest 30 miles, very heavy sea on lake and much damage to shipping and wharves. Saint Vincent, Minn., 16th, violent storm from the north, highest velocity 40 miles per hour. St. Paul, violent gale from north-northwest, considerable damage in country and city, all telegraphic communication interrupted. Yankton, Dak., 16th, 70 miles, northeast at 1 A.M.; roads blocked with snow and communication of all kind suspended. Snow-drifts east of station reported

to be from 10 to 15 feet high. Reports from different points estimate loss of cattle and crops in Yankton County, at $5,000. Fort Bennett, Dak., 16th, north, 40 miles. Memphis, Tenn., 15th, 32 miles west, much damage to buildings in city. Little Rock, Ark., 15th, west 32 miles, considerable damage to bridges, fences, and buildings.

Sand-storms.—Umatilla, Oreg., 13th; Winnemucca, Nev., 7th, 8th, 14th, 28th; Fort Yuma, Cal., 8th, 15th; Fort Garland, Colo., 22d.

ATMOSPHERIC ELECTRICITY.

Thunder-storms.—Comparatively few have been reported during the month, and mostly from the northern sections of the country. The most extensive, as well as severe, was that of the 15th and 16th. Distributed among the several States, they were reported on the following dates: *Maine:* 23d. *Massachusetts:* 12th, 23d, 25th, 30th, and 31st. *New York:* 3d, 12th, and 16th. *Virginia:* 15th, 22d, 30th. *North Carolina:* 22d. *Florida:* 3d, 5th, 7th, and 28th. *Tennessee:* 3d, 14th, 15th, 16th, and 26th. *Kentucky:* 14th and 15th. *Ohio:* 1st, 2d, 14th, 15th, 17th, and 21st. *Indiana:* 1st and 15th. *Illinois:* 1st, 2d, 3d, 14th, 15th, 21st, 24th, and 25th. *Michigan:* 1st, 3d, 4th, 15th, and 25th. *Wisconsin:* 10th and 16th. *Iowa:* 1st, 2d, 3d, 10th, 11th, 13th, 15th, and 24th. *Missouri:* 15th and 25th. *Mississippi:* 27th. *Louisiana:* 3d, 27th, and 28th. *Texas:* 2d, 3d, 13th, 15th, 16th, 21st, 26th, and 27th. *Indian Territory:* 13th, 15th, and 25th. *Kansas:* 2d and 20th. *Nebraska:* 2d, 3d, and 13th. *Colorado:* 26th. *New Mexico:* 24th.

Auroras.—The most extensive occurred on the evenings of the 7th, 28th, and 30th, and the early morning of the 31st, and were reported by various observers, both Signal Service and voluntary, from stations reaching eastward from Dakota to Maine, and southward to the 37th parallel.

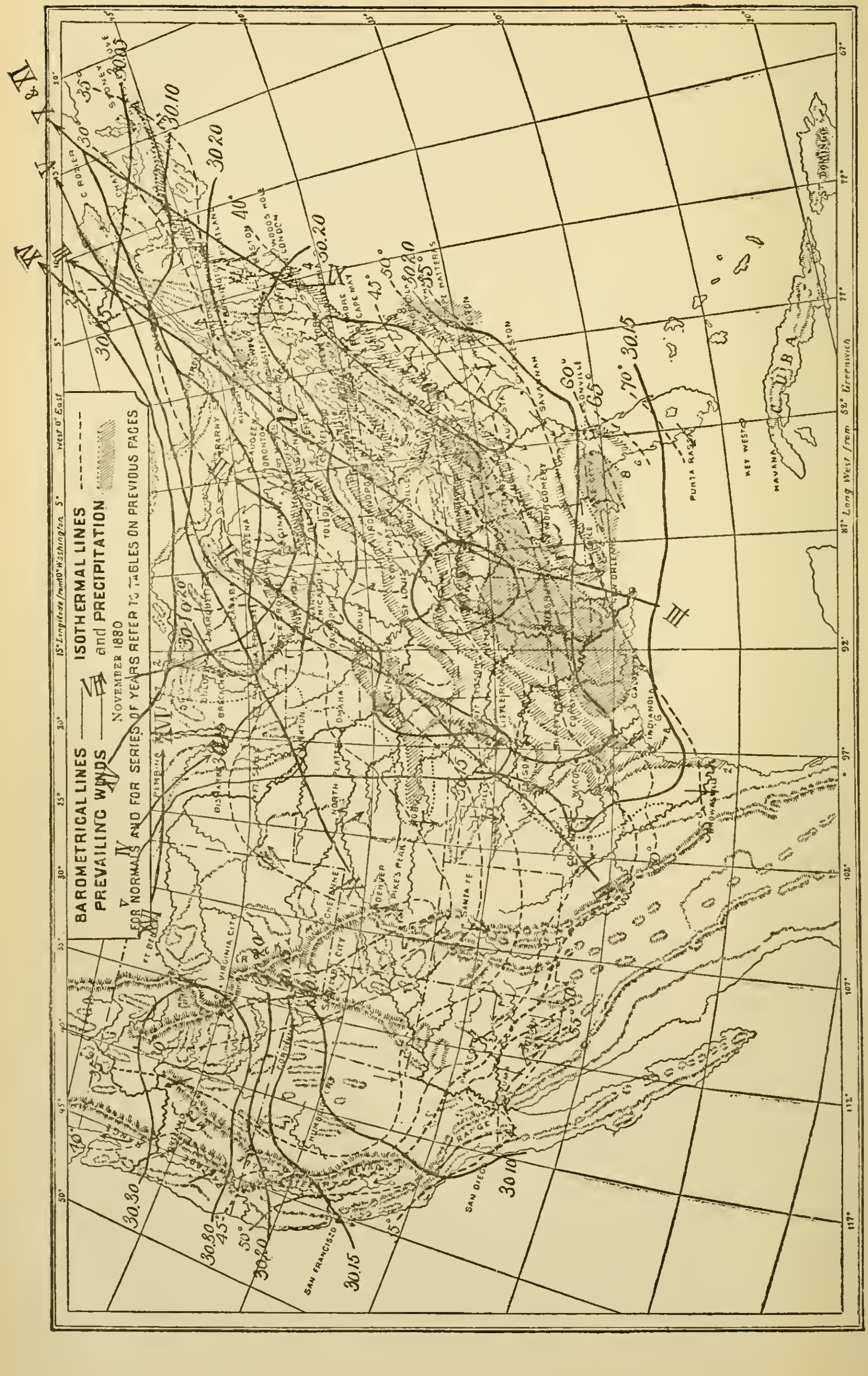
AQUEOUS VAPOR IN RELATION TO PERPETUAL SNOW.

BY JAMES CROLL, LL.D., F.R.S.

Some twelve years ago I gave (*Phil. Mag.*, March, 1867, "Climate and Time," p. 548) what appears to be the true explanation of that apparently paradoxical fact observed by Mr. Glaishier, that the difference of reading between a thermometer exposed to direct sunshine and one shaded diminishes instead of increases as we ascend in the atmosphere. This led me to an important conclusion in regard to the influence of aqueous vapor on the melting of snow, but recent objections to some of my views convince me that I have not given to that conclusion the prominence it deserves. I shall now state in a few words the conclusion to which I refer.

The reason why snow at great elevations does not melt, but remains permanent, is owing to the fact that the heat received from the sun is thrown off into stellar space so rapidly by radiation and reflection that the sun fails to raise the temperature of the snow to the melting point; the snow evaporates but does not melt. The summits of the Himalayas, for example, must receive more than ten times the amount of heat necessary to melt all the snow that falls on them, notwithstanding which the snow is not melted. And in spite of the strength of the sun and the dryness of the air at these altitudes, evaporation is insufficient to remove the snow. At low elevations, where the snow-fall is probably greater, and the amount of heat received even less than at the summits, the snow melts and disappears. This I believe we must attribute to the influence of aqueous vapor. At high elevations the air is dry and allows the heat radiated from the snow to pass into space, but at low elevations a very considerable amount of heat radiated from the snow is absorbed by the aqueous vapor which it encounters in passing through the atmosphere. A considerable portion of the heat thus radiated, being of the same quality as that which the snow itself radiates, is on this account absorbed by the snow. Little or none of it is reflected like that received from the sun. The consequence is that the heat thus absorbed accumulates in the snow till melting takes place. Were the amount of aqueous vapor possessed by the atmosphere sufficiently diminished, perpetual snow would cover our globe down to the sea-shore. It is true that the air is warmer at the lower level than at the higher level, and by contact with the snow must tend to melt it more at the former than at the latter position. But we must remember that the air is warmer, mainly in consequence of the influence of aqueous vapor, and that were the quantity of vapor reduced to the amount in question, the difference of temperature at the two positions would not be great.

But it may be urged, as a further objection to the foregoing conclusion, that as a matter of fact on great mountain-chains, the line reaches to a lower level on the side where the air is moist, than on the opposite side where it is dry and arid. As, for example, on the southern side of the Himalayas and on the eastern side of the Andes, where the snow-line descends some 2,000 or 3,000 feet below that of the opposite, or dry side. But this is owing to the fact that it is on the moist side that by far the greatest amount of snow is precipitated. The moist winds of the S.W. monsoon deposit their snow almost wholly on the southern side of the Wimalayas, and the S.E. trades the snow on the east side of the Andes. Here the conditions in every respect the same on both sides of the mountain ranges, with the exception only that the air on one was perfectly dry, allowing radiations from the snow to pass without interruption into stellar space, while on the other side the air was moist and full of aqueous vapor, the snowline would descend to a lower level on the dry than on the moist side.—*Amer. Jl of Science,* No. 116, vol. xx., Aug. 1880.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
NOVEMBER 1880
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES

5. MONTHLY WEATHER REVIEW, NOVEMBER, 1880.

BAROMETIC PRESSURE.

Upon the Chart is shown, by the isobaric lines, the distribution of atmospheric pressure over the United States for November, 1880. On the Pacific slope an area of unusually high pressure prevailed over Oregon and Washington Territory, the mean being above 30.30 at all Oregon stations. An area of very high pressure covered the Middle States and the Ohio Valley and Tennessee, the mean ranging in these districts from 30.22 to 30.29. Except at the Rocky Mountain stations, in the Plateau districts, the South Atlantic and Eastern Gulf States, the mean pressures have been decidedly greater than have ever before been recorded by this service in November.

Departures from normal values for the month.—By comparison with the average for seven years, it is found that the barometric pressure for November, 1880, except in the Plateau and Rocky Mountain districts (where the departures from the normal have been slight and unimportant), has been very decidedly above the average. The excess in New England, the Middle States, the Lower Lake region, and the Ohio Valley, has ranged from 0.16 inch to 0.20; elsewhere, except along the immediate Gulf coast, it varied from 0.10 to 0.19. On the Pacific coast, the excess was 0.08 at San Diego, 0.12 at San Francisco, and 0.20 at Portland.

The local barometric ranges, from readings reduced to sea-level, have, during November, 1880, been greater than usual. These ranges, eastward of the 102d meridian, as a rule, increase from the coast toward the interior, so that lines of equal ranges are generally parallel to the seacoast. In the Gulf States the lines deviate slightly from this rule, and trend from the northeast to the southwest—the fluctuations in Texas being decidedly greater than in Florida. The local ranges for the month decrease gradually along the Gulf coast from 0.92 at Indianola to 0.36 at Punta Rassa and Key West. Along the Atlantic coast they increase gradually from 0.51 at Jacksonville to 1.23 at Portland, Me. The greatest fluctuations occurred over the Lake region and the Ohio Valley; greatest ranges, 1.44 inches at Marquette, 1.45 at Columbus, 1.48 at Madison and Rochester, and 1.50 at Buffalo. In the elevated plateaus of the country the range increases quite regularly with the latitude, while on the Pacific slope the lines of equal ranges trend from northwest to southeast, indicating that the range increases with latitude

and elevation. The greatest ranges on that coast were 1.19 at Olympia and 1.42 at Umatilla.

General barometric range.—The extreme range of the atmospheric pressure, reduced to sea-level, was 1.75 inch, from 30.86 at Cincinnati on the morning of the 22d to 29.11 at Father Point on the afternoon of the 7th.

Areas of high temperature.—Nine such areas have prevailed during November, 1880; two of these areas were encroachments of the area of high pressure from the North Pacific Ocean. No. VI. appears to have been formed by an encroachment of high pressure from the Pacific Ocean together with an outflow from Saskatchewan. No. III. appeared first in Texas, although it may have moved eastward from the Plateau districts. Nos. III., VII., and VIII. were especially noted for the unusually high pressures and very low temperatures for the season. In consequence, the pressure has been abnormally high, and the temperature proportionally low.

No. VII.—This area, the most important of the month, was apparently an outflow of dry, cold air from Saskatchewan or Manitoba. During the 20th the pressure rose rapidly in the Missouri Valley, and at midnight was central in Missouri; Omaha and Leavenworth barometers 0.39 above the normal. Moving slowly eastward the pressure was increased by an additional outflow of cold air from Hudson's Bay Territory, so that while the centre remained nearly stationary in the Ohio Valley during the 22d and 23d, the pressure at Cincinnati rose to 30.85 or 0.67 above the normal, the highest pressure ever noted at that station. As this area withdrew eastward from the Ohio Valley to the Middle States during the 23d, advancing high area No. VIII. united with it. Its subsequent history is considered as that of No. VIII. Cautionary signals were ordered for the North Carolina coast, and naving been justified were continued until the 26th in connection with high area No. VIII. The passage of this area was marked by minimum temperatures for the Lake region, the Atlantic States, the Ohio, Upper Mississippi, and Lower Missouri Valleys. Except in New England, these temperatures were remarkably low for November. They occurred from seven to eight days earlier in the month than the remarkably low temperatures of 1875. The most notable temperatures observed at Signal Service stations were: Washington, 12.5°; Philadelphia, 10°; Saint Louis and Louisville, 8°; Pittsburgh, 4°; Buffalo, 3°; Chicago, 1°; Erie, Detroit, Sandusky, Grand Haven, and Des Moines, 0°; Champaign, —3°; Alpena, —4°; Columbus, Indianapolis, Keokuk, and Milwaukee, —5°; Port Huron, —6°; Marquette, —9°.

Areas of low pressure.—Sixteen areas are described for November, 1880. Eleven of these areas have followed tracks sufficiently well defined to permit the charting of them. Of these areas, Nos. III., VI., and XI. were possibly of cyclonic origin. Four originated in the Rocky

Mountain districts, one developed in Minnesota, and the remaining areas probably formed in Saskatchewan or Hudson's Bay Territory. No area, except possibly No. V., originated on the Pacific coast. Nos. III., V., VII., and X. were storms of marked and unusual violence in the Lake region, and caused the loss of many lives and destruction of many vessels. The severity of the storms in the early part of the month on Lake Ontario may be inferred from the statement that during the first twelve days of the month the crew of the Oswego life-saving station rescued forty-five persons, thirty-nine of whom were saved from wrecks. No. XI. proved to be an unusually severe storm along the New England coast, the Canadian maritime provinces, and Newfoundland. The extreme violence of these storms has in a large measure been occasioned by the rapidity with which the low areas have been followed by areas of high pressure.

No. III.—This storm, which was one of marked and unusual violence in the Lower Lake region, was possibly of cyclonic origin. At midnight of the 5th a sharp barometric fall was reported from the central coast of the Gulf States; New Orleans and Mobile barometers 0.22 below the normal. On the morning of the 6th a trough of decreased pressure extended from Alabama northward to Ohio; Knoxville, Nashville, and Columbus barometers 0.34 below the normal. During the day the pressure rapidly decreased, being that afternoon 0.60 below the normal at Columbus, and at midnight 0.86 below at Kingston. Moving rapidly northeastward it was central in the lower Saint Lawrence Valley on the morning of the 7th, and later in the day passed over the Gulf of Saint Lawrence. At midnight of the 5th signals displayed for area No. II. were continued on the lower lakes, and all stations were warned of this advanced storm. This storm, in connection with advancing high area No. III., was unusually severe in the Lower Lake region and New England. The storm on Lake Erie was said to have been the worst for thirty years. Rain or snow, with northerly backing to westerly gales, prevailed, with wind velocities as follows: Sandusky, W., 43; Erie, N.W., 44; Toledo, W., 44. At Toledo many vessels warned remained in port; all venturing out were obliged to put in for shelter, and one was lost. Two schooners and three barges were driven ashore, and others were severely damaged. On Lake Ontario the storm was even more severe. During the 7th the wind attained velocities of W. 36 at Oswego, W. 44 at Rochester, and W. 60 at Buffalo. On that morning the propeller Zelanda foundered; crew, sixteen in number, all lost. One schooner and crew of seven were lost, and one passenger steamer and one schooner missing, probably lost. Four other steamers, one barge, and one scow were driven ashore, and several vessels badly damaged. Many vessels remaining in the harbor at Buffalo escaped the storm; all others leaving port were driven back badly damaged. At Buffalo the storm was very violent, doing considerable damage to prop-

erty; the mean hourly velocity of the wind for the twelve hours preceding 12 M. of the 7th was forty-three miles. Part of Main street was submerged by high water. At Utica the storm was very violent, unroofing a church and damaging other property. A violent thunder-storm occurred at Poughkeepsie at 2 P.M. of the 7th. During the morning violent gales occurred at Toronto and the greater part of the Province of Ontario. Much damage was done to houses and other buildings at Canandaigua, Palmyra, and other portions of Western New York. During the 6th cautionary signals were displayed along the Atlantic coast from North Carolina to Maine, and were changed later from cautionary signals to off-shore from Cape Hatteras to Portland; they were lowered at the afternoon and midnight reports of the 7th; these signals were fully justified by southeasterly veering to northwesterly gales, with the following maximum velocities: Portland, S.E., 31, and N.W., 34; Boston, W. 32; Eastport, S., 36; New Shoreham, S.W., 36; Cape Hatteras, N.W., 36; Kittyhawk, S.W., 44; Wood's Holl, N.W., 42, and S.W., 45; Cape May, W., 62. Very severe weather was reported from Long Island Sound and off the New England coast. At Thatcher's Island the Signal Office building was unroofed by the gale. Strong westerly gales prevailed in the Canadian maritime provinces during the 8th; Father Point, wind in the afternoon and midnight W. 55 miles. During the 7th and 8th, strong westerly gales and high seas were reported by incoming European steamers.

No. V.—During the 6th the pressure fell rapidly on the North Pacific coast, and on the morning of the 7th the barometer at Olympia was 0.17 below the normal. The centre, considerably to the northward of the Signal Service stations, by a southeasterly course, reached Northern Dakota on the morning of the 8th; Bismarck barometer 0.52 below the normal. At that time an extensive trough of low pressure covered the country from the Plateau districts eastward to the Mississippi Valley. During the day, the pressure rose in the Missouri Valley, and the centre of this area moved due south to Northern Texas, where it was central the afternoon of the 9th. Changing its course to north-northeast, it was central, with decreasing pressure, the morning of the 10th in Iowa (Keokuk barometer 0.63 below the normal), and on the morning of the 11th in Northern Michigan; Marquette barometer 0.66 below normal. Changing its course to the eastward through Canada, considerably to the north of the Signal Service stations, it reached the Gulf of Saint Lawrence the afternoon of the 12th. Cautionary signals were ordered for the Texas coast during the 8th, and were changed, as the area moved eastward, to off-shore. Maximum velocities of S.W. 40 and N.W. 40, were reported from Indianola. Cautionary signals were displayed at Pensacola on the 9th, justified by a wind of S.W. 25 miles. Considerable damage was done to vessels in Pensacola Harbor. As this area moved northeastward from Texas at midnight of the 9th,

cautionary signals were displayed on Lake Michigan, and were ordered the following morning for the rest of the Lake region and along the Atlantic coast from Chincoteague to Wood's Holl. These signals were changed to off-shore on the New Jersey coast the morning of the 11th, and along the New England coast the morning of the 12th. They were lowered during the 12th, as follows: On Lakes Superior and Michigan, in the morning, Lakes Huron and Erie, Long Island Sound, and the New Jersey coast in the afternoon, and at the remaining stations at midnight. These signals were all fully justified; the greatest wind velocities reported were as follows: Duluth, N.W., 32; Alpena, N.E., 33; Cleveland and Erie, S.W., 34; Buffalo, W. 37; Milwaukee, S.W., 34; Thatcher's Island, S.E., 33, and W. 33; New Shoreham, S. E., 34, and W. 32; Eastport, S.E., 34; Wood's Holl, W., 44, and N.W., 44. This gale was very severe in the Lake region, along the New England coast, and in the Gulf of Saint Lawrence. The wind velocities at Father Point on the 13th were as follows: A.M., W., 50; P.M., W., 44; M., N.W., 40. On Lakes Erie and Ontario, in addition to the foundering of the schooners Norway and Morning Star, by which 15 lives were lost, many vessels were seriously damaged and a number driven ashore.

No. VII.—This area moved southeastward from Manitoba, and on the morning of the 15th was central in Minnesota; Duluth barometer 0.48 below the normal. The centre continued in a southeast course and, passing over Lake Michigan, was central, with increased pressure in Southern Michigan the morning of the 16th, whence it passed northeastward into Canada during that day. Cautionary signals were ordered for the Upper Lake region at midnight of the 14th, and for the stations on the other Lakes, except Ontario, the following day. They were lowered on the Upper Lakes during the 15th, and at the Lower Lake stations on the following morning. These signals were justified by rough weather and high winds, the schooner E. M. Carrington being lost, with a crew of five, on Lake Michigan, and three vessels foundered or totally wrecked (crews saved) on Lake Erie. The following are some of the maximum velocities which were reported: Buffalo, S.W., 25; Toledo, S.W., 27; Marquette, W., 27; Duluth, N.W., 30; Grand Haven, N.W., 32; Port Huron, W., 33.

No. X.—During the 18th the pressure gradually decreased over the Plateau regions, and by midnight this area was central in Nebraska; Cheyenne barometer 0.23 below the normal. Moving northeastward, the centre, on the morning of the 20th, was over the eastern end of Lake Superior, whence it passed eastward, with increasing violence, through Canada and reached the Saint Lawrence Valley at midnight. On the morning of the 21st, it united over the Gulf of St. Lawrence, with low area No. XI. On the morning of the 20th, cautionary signals were ordered for Lakes Michigan, Huron, and Erie, and that afternoon for Lake Ontario. These signals were lowered on the 21st in the Upper

Lake region and on the following morning at the Lower Lake stations. This storm was unusually severe over Lake Ontario, where four vessels were wrecked and ten others badly damaged. At Buffalo one vessel was sunk, and one person drowned. The following maximum velocities were reported: Marquette, W., 26; Milwaukee, W. 36; Alpena and Port Huron, W., 34; Erie, S.W., 42; Oswego, W., 33; Buffalo, W., 37.

No. XI.—During the night of the 19th and 20th, the pressure decreased rapidly along the South Atlantic coast. On the morning of the 20th the barometric fall extending northward, became more sudden and marked; New London barometer 0.34 below the normal (a fall of 0.39 in eight hours), Cape Hatteras barometer 0.31 below the normal (a decrease of 0.20 in eight hours). The lowest pressure connected with area No. X. was then 0.30 below the normal at Parry Sound. At midnight this area was central over the Bay of Fundy, with the following decrease of pressure reported for the past eight hours: Sydney, 0.38 inch; Father Point, 0.39; Chatham, 0.50; Halifax, 0.59; Eastport, 0.61, and Yarmouth, 0.71. On the morning of the 21st the area united with No. X. over the Gulf of Saint Lawrence; Sydney barometer 29.29 or 0.61 below the normal (a fall of 0.71 in eight hours and 1.09 in sixteen hours). Cautionary signals were displayed during the 20th for New England and the North Carolina coast, and were lowered, in the latter district, at midnight. Cautionary off-shore signals were also ordered for the New Jersey coast. In New England, except for Eastport, these signals were later changed to off-shore. These signals were lowered on the New Jersey coast on the morning of the 21st, but were continued at the remaining stations until the morning of the 22d. This storm was one of unusual violence off the New England coast, the Canadian maritime provinces, and off the Banks of Newfoundland, continuing in the latter district until the 25th. A dispatch from Saint John's, N. F., reports that over thirty vessels were lost; fourteen in Bona Vista Harbor, six in Conception Bay, several in Green Bay. The following are some of the wind velocities reported: Portland, W., 31; New Shoreham, N.W., 42; Boston, W., 44; Wood's Holl, N.W., 44; Thatcher's Island, N.W., 40; Yarmouth, N., 55; Father Point, 21st, A.M., W., 48, P.M., W., 84, M., W., 65; 22d, A.M., W., 54, P.M., W., 60 M., W., 48.

TEMPERATURE OF THE AIR.

The mean temperature of the air for November, 1880, is indicated by isotherms on the Chart. The mean in every district of the country has been below the normal. Such deviations from the normal exceeded 5° over the entire country, except California, the Atlantic and East Gulf States, and the Lake Ontario region. The following are the most notable departures at various stations: St. Louis, Indianapolis, Indianola, Corsicana, Brownsville, and Denison, from 10.2° to 11.0°; San An-

tonio, North Platte, Concho, and Laredo, from 10.5° to 12.1°; Fort Gibson 12.6°; Cheyenne 13°; Rio Grande City and Fort Griffin, Texas, 13.1°; Fort Davis, Texas, and Dodge City, 13.7°, and Denver, 16.3°. Except in the Atlantic States and the Lake Ontario region (where either November, 1873, or 1875, was slightly colder), the present month has been the coldest since the establishment of the Signal Service stations. From detached stations, not included in districts, the following departures from the mean are noted: Mount Washington, 2.3° below; Pike's Peak, 11-2°; Key West, 3.6° below; Punta Rassa, 5.4° above. In connection with the extremely low temperature of the month, and the deficiency of temperature in Northern Florida and at Key West, it is particularly noticeable that the mean temperature at Punta Rassa should be the highest of any year since its establishment in 1871; November, 1873, only excepted.

PRECIPITATION.

The general distribution of rain-fall (including melted snow) for November, 1880, is shown on the Chart, as accurately as possible, from about five hundred reports. The belt of greatest rain-fall extended from the mountain region of North Carolina southwestward to Eastern Texas. Southern Arizona is the only section of country over which no rain has fallen during the month. The rain-fall in New England and the Middle Atlantic States continues deficient. In the first district, the deficiencies since January 1st, 1880, amount to 6.51 inches, in the latter to 4.60. A marked excess has been reported from Tennessee, the South Atlantic and Gulf States, amounting in the Western Gulf district to 3.38 inches—the greatest excess of the month. The departures from the average precipitation at certain stations in the last-named district were as follows: Corsicana, 2.05, above; Shreveport, 2.89 above; Galveston, 3.30 above; and Vicksburg, 9.52 above; the rain-fall at the last station was over three times the normal amount. On the Pacific coast, the rainfall has been generally deficient, being only about one-third of the average. In districts not named, the deviations from the normal rain-fall have been less important.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 9 to 21. Middle Atlantic States, 7 to 18. South Atlantic States, 13 to 21. Eastern Gulf States, 7 to 18. Western Gulf States, 11 to 22. Ohio Valley and Tennessee, 13 to 17. Lower Lake region, 17 to 24. Upper Lake region, 12 to 18. Upper Mississippi Valley, 9 to 14. Lower Missouri Valley, 6 to 15. Valley of the Red River of the North, 9 to 14. Texas, 2 to 17. Rocky Mountains, 0 to 14. Middle Plateau, 1 to 13. California, 1 to 3. Oregon, 4 to 11.

Cloudy days.—The number varies in New England from 3 to 18. Middle Atlantic States, 5 to 15. South Atlantic States, 14 to 20. Eastern Gulf States, 2 to 18. Western Gulf States, 13 to 19. Ohio

Valley and Tennessee, 10 to 17. Lower Lake region, 13 to 20. Upper Lake region, 10 to 19. Upper Mississippi Valley, 9 to 14. Missouri Valley, 9 to 12. Valley of the Red River of the North, 6 to 9. Texas, 10 to 19. Rocky Mountains, 3 to 9. Middle Plateau, 3 to 9. California, 1 to 4. Oregon, 9 to 12.

Droughts.—Wellington, Kans., 30th, streams and springs drying up. Mendon, Mass., 30th, many wells dry. Westborough, Mass., 30th, brooks, springs, and wells very low. Antrim, N. H., streams unusually low.

Snow from cloudless sky.—Lawrence, Kans., 27th. New Ulm, Minn., 28th. Santa Fé, 5th.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, 63 to 75. Middle Atlantic States, 66 to 90. South Atlantic States, 65 to 83. Eastern Gulf States, 69 to 83. Western Gulf States, 64 to 82. Ohio Valley and Tennessee, 64 to 80. Lower Lake region, 69 to 75. Upper Lake region, 66 to 86. Upper Mississippi Valley, 63 to 71. Lower Missouri Valley, 60 to 79. Red River of the North Valley, 78 to 85. Texas, 66 to 82. Middle Plateau, 36 to 59. California, 43 to 59. Oregon, 74 to 83. High stations report the following percentages not corrected for altitude: Mount Washington, 88.6; Pike's Peak, 60.6; Santa Fé, 55.2; Cheyenne, 56.1; Denver, 64.3.

WINDS.

The prevailing winds at Signal Service stations are shown on the Chart by arrows which fly with the wind. Westerly winds have prevailed in the Lake region and New England; northwesterly winds in the Middle States; northeasterly in the South Atlantic and East Gulf States; elsewhere east of the Rocky Mountains they have been northerly, except in the Upper Mississippi Valley, where they were from northwest to southwest.

High winds.—On Mount Washington a velocity of 105 miles, N.W., occurred on the 21st, and 102, N.W., on the 7th and 12th. Maximum velocities, ranging from 52 to 96 miles, occurred on eighteen other days; these high winds were from the northwest on all but five days, four from the south, and one from the southwest. Maximum velocities, exceeding fifty miles or more, occurred elsewhere as follows: Kittyhawk, N., 50, on the 23d; Cape Lookout, E., 50, on the 4th; Buffalo, S.W., 52, on the 7th; Cape May, N.W., 60, on the 21st; Pike's Peak, W., 70, on the 20th.

The following are the largest total movements in the various districts: Pike's Peak, 15,645. Cape Lookout, 12,763. Wood's Holl, 12,316. Indianola, 12,109. Cape May, 11,667. New Shoreham, 11,602. Mount

Washington, 10,087, incomplete on account of frost-work. Sandusky, 8,976. North Platte, 8,827. Alpena, 8,202. Breckinridge, 8,112. Bismarck, 8,085. Winnemucca, 6,040. The smallest are: Roseburg, 1,135. La Mesilla, 1,208. Visalia, 1,580. Lynchburgh, 1,722. Augusta, 2,066. Salt Lake City, 2,090. Uvalde, 2,620. Helena, 2,838. Nashville, 2,893. Leavenworth, 3,031. Springfield, Mass., 3,068.

Local storms, worthy of record, have been noted in connection with the various high and low areas, except as follows: A violent tornado at Keachi, De Soto Parish, La., at 4.30 P.M., November 9th. Its course was from north to south, in a path about 250 yards wide; length from eight to ten miles. On Moore's plantation, four miles distant, a gin-house was blown down, killing one man and four mules. The chapel and other buildings connected with the Baptist Female College at Keachi were unroofed or badly damaged; seven other buildings were torn to pieces or much damaged. In Keachi one person was killed and nine were injured, three seriously.

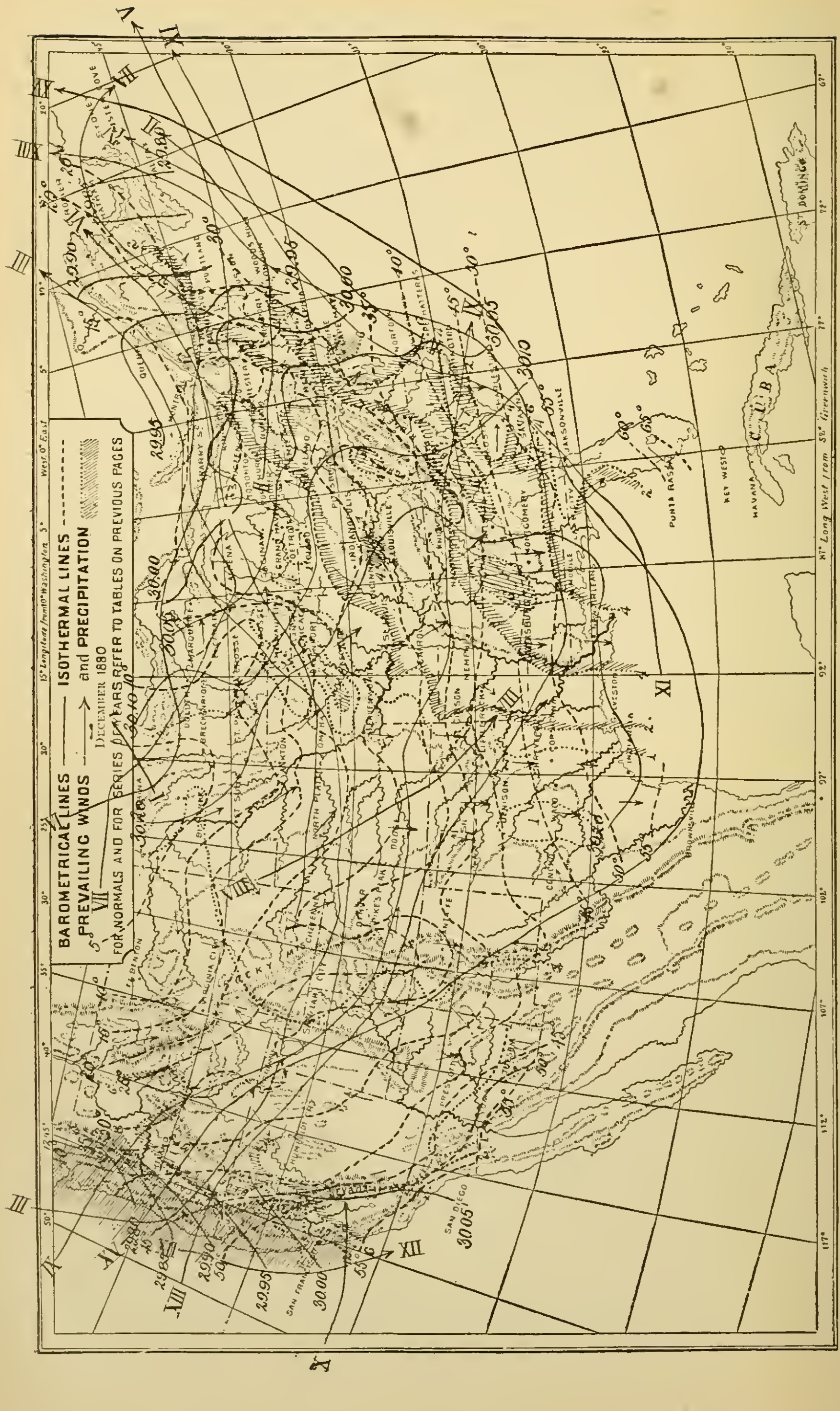
Whirlwind.—Yuma, Cal., 21st, travelling from southwest to northeast; cloud funnel-shaped; upper end lagged behind so as to incline the column about 70° from the perpendicular; cloud about 10 feet in diameter and appeared to revolve from left to right.

Sand-storms.—Visalia, Cal., 17th, 18th, very severe on the 19th, killing large numbers of sheep. Umatilla, Oreg., 7th, very severe. Near Mammoth Tank, Cal., 16th, worst ever known; stopped railway traffic for sixteen hours.

ATMOSPHERIC ELECTRICITY.

Thunder-storms have been comparatively rare, except in the Gulf States. Storms were reported from more than one station in that district on the 4th, 5th, 8th to 10th, 12th, 16th, 19th, and 30th.

Auroras.—On the 1st the aurora was visible in Maine, Vermont, and at Bismarck, Dak. On the 2d and 3d it was observed generally in New England, New York, and New Jersey. The most southerly station reporting it on the former date was Somerville, N. J., and on the latter date, Moorestown, N. J. It was also observed on the 2d at Saint Vincent, Minn., and on the 3d at Dayton, Wash. On the 21st a display was observed at Newport, R. I., Wellsboro, Pa., and Lansing, Mich. On the 30th a display was general in the northern part of New England; the most southerly station reporting was Somerset, Mass.; it was noted the same day at Oswego, Port Huron, and Breckinridge. Isolated displays are reported from New England under dates of the 4th, 6th, and 10th, inclusive, from Pennsylvania on the 23d and 26th, from Iowa on the 14th, 25th, and 29th, Dakota on the 9th, from Minnesota on the 20th, 23d, 27th, and 29th, and from Nebraska on the 28th, from Indiana on the 20th, from Michigan on the 22d.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
DECEMBER 1880
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES
CUBA
KEY WEST
HAVANA
PUNTA RASSA
JACKSONVILLE
SAN DIEGO
ST. DOMINGO

6. MONTHLY WEATHER REVIEW, DECEMBER, 1880.

BAROMETRIC PRESSURE.

Upon the Chart is shown, by the isobaric lines, the distribution of atmospheric pressures over the United States for December, 1880. The area of highest pressure lies somewhat farther westward than usual and covers the greater part of the country from the Mississippi Valley westward to the Eastern Rocky Mountain slope. On the Pacific slope, the high pressure prevailed on the southern instead of the northern coast.

Departures from normal values for the month.—By comparison with the average for the past eight or nine years, it is found that the barometric pressure for December, 1880, ranged from 0.05 inch to 0.10 below the mean in the Atlantic States; greatest departures, −0.10 at Norfolk and Wilmington, and −0.12 at New Haven and Wood's Holl. Over the Missouri and Upper Mississippi Valleys, an equal excess of pressure prevailed; greatest departures, +0.05 inch at Keokuk, La Crosse and Saint Paul in the latter, and +0.11 at Bismarck and Yankton in the former district. On the Pacific coast, the pressure was normal at San Diego, 0.10 below it at San Francisco, and 0.24 below at Portland, Oreg.

Local barometer ranges, from readings reduced to sea-level, were greater than usual, and exceeded 0.75 inch over the entire country, except Southern Florida, Southern California, and at a few scattered stations in the Southern Plateau district. The ranges in the Atlantic and Gulf States generally varied but little from 1 inch. The greatest ranges were in that portion of the Lake region and Upper Mississippi Valley over which the centre of low area No. V. passed; they increased gradually northeastward from 1.47 at Leavenworth to 1.79 (the largest in the country) at Escanaba. The smallest range was 0.49 at Key West. Other noticeable ranges were 1.70 at Dodge City, 1.48 at Missoula, and 1.27 at Umatilla.

General barometer range.—The extreme range of the atmospheric pressure, reduced to sea-level, was 2.15 inches, from 30.97 at Fort Buford on the 26th to 28.82 at Dodge City on the 4th.

Areas of high pressure during December, 1880, were eight in number, three of which were slight and unimportant encroachments of high pressures from the Pacific Ocean. The five other areas were outflows of very cold air from the British Possessions, and, except No. V. (which seems to have moved southward from Hudson's Bay), advanced southeastward, apparently from Saskatchewan. No. VIII. was the most important area,

its passage being marked from the 24th to the 31st by excessively low temperatures which materially reduced the mean temperature of the month, and made in many sections the last half of the month the coldest for many years.

No. VIII. was the most important high area of the month. It first showed itself by a marked rise in barometer over the valley of the Upper Missouri during the 24th; the next morning the temperature at Fort Garry was −35°. The pressure remained nearly stationary until the 26th, when a second rise carried the pressure at Fort Buford to 30.97. The area covered the Missouri Valley until the 28th, when it moved rapidly southeastward, being central in Texas on the 29th; midnight barometer at Eagle Pass 30.65 or 0.52 above the normal. A portion of the area remaining in Texas slowly dissipated, while another part moving northeastward covered the Atlantic slope with a pressure decidedly above the mean during the 31st; Cape Henry barometer that morning 0.30 above the normal. Cautionary signals were displayed on Lake Michigan on the 27th (highest velocity 35 miles at Milwaukee) and on the 29th (40 miles at Grand Haven). The minimum temperatures which prevailed during the passage of this area east of the Rocky Mountains were the lowest observed over the greater part of the country for many years. As the area moved southeastward on the morning of the 28th a minimum temperature of −44° was reported from Fort Garry. At that time the temperature of the Missouri and Upper Mississippi Valleys, the Upper Lake region, and the North Rocky Mountain slope was below zero. On the morning of the 29th the area over which temperatures below zero prevailed was extended to include the Ohio Valley and the northern parts of Indian Territory and Texas, while at Fort Benton, Montana, a temperature of −59° was observed. This temperature (that observed at Pembina on December 24th, 1879, being the same) is the lowest ever recorded in the United States, and is within 14.8° of the lowest ever reported on this continent (British Arctic Expedition of 1875–'76, −73°.8 at Floeberg Beach, 82° 27′ N. 173° 26′ W. in March, 1876). On the morning of the 30th, temperatures ranging from 0° to −56° were reported from the entire Lake region, the Ohio, Upper Mississippi, and Upper Missouri Valleys, the Rocky Mountain slope southward to include the northern parts of Texas and New Mexico, from the greater part of New England, from the Middle States (except Southeastern Virginia), from the western half of North Carolina and Eastern Tennessee. On the 31st, temperatures below zero prevailed over substantially the same region, with the addition of the greater part of New Mexico and portions of Texas and New England. On that and the preceding morning freezing temperatures prevailed over the entire United States except the Pacific coast region, the southern half of Florida, and the extreme southwestern portion of Arizona. The following temperatures in Arizona and the Gulf States are noted as of interest:

Tucson 35°, Cedar Keys 22°, New Orleans 20°, Jacksonville 19°, Brownsville 18°, Mobile 14°, Montgomery 8°, Augusta 7°. Much damage was done by the low temperature of this area to the sugar cane in Louisiana and adjoining States. Timely and sufficient warning, however, was given to planters so that they could take such means as would save the largest possible amount of the cane.

Areas of low pressure.—Sixteen such areas appeared during December, 1880. The tracks of thirteen are shown by the Chart. An unusually large number of these areas, six in number, first appeared on the Pacific coast; four of the number crossed the continent. One area sprang up in the Lower Lake region, one in North Carolina, two in the Gulf of Mexico, and three from the Rocky Mountain region; the three remaining probably developed in Saskatchewan. No. III., as a whole, was the most severe storm, being violent on the Pacific slope, accompanied by tornadoes in Missouri, and marked in the Lake region by the lowest pressures and highest winds of the month. Nos. X., XII., and XIII. caused strong gales off the Pacific coast, and in connection with the last-named area, most violent northeast to northwest gales prevailed from North Carolina to Nova Scotia during the 25th and 26th. No. XV. was marked by very severe gales in the Gulf of Mexico, and along the entire Atlantic coast during the 29th. This area moved with unusual rapidity, its velocity east of the 100th meridian averaging seventy-five miles per hour. The paths pursued by areas for the first half of the month were, through their whole extent and without exception, to the northward of the 40th parallel. During that time the pressure over the country was comparatively low. During the latter half of the month the pressure over the country at large was decidedly above the normal, and at no time gave way so as to permit the natural movement of the low areas eastward. In consequence the tracks of low areas skirted the borders of the prevailing high pressures. The areas on the Pacific slope moved southeastward along the coast, and such as have crossed the continent passed southeastward through Texas, and skirting the northern coast of the Gulf of Mexico, moved northeastward along the Atlantic coast.

No. III.—This storm was unusually violent on the Pacific coast. Off Columbia River, heavy W.S.W. gales, veering to N.W. were experienced from November 29th to December 3d, and off the coast of Southern Oregon during the 2d and 3d; lowest barometer 29.12, reported by the steamer Elder. During the 2d, along the entire coast of California, heavy southerly gales occurred, in which one or more vessels were lost. The storm apparently moving from the northwest, entered Oregon during the 2d; Roseburg barometer that morning, 29.26 or 0.91 below the normal. Moving very slowly southeastward, it was central in Utah at midnight of the 3d. Its passage through California and Nevada was marked by heavy rains. At San Luis Obispo the rain-fall of the storm

was 4.65 inches and at Mount St. Helena 6.65. In the Sierra Nevada Mountains along the Central Pacific Railway, four feet of snow fell upon a level. Railway travel was somewhat delayed by dangerous land-slides and heavy snow. In Western Oregon, the snow-fall was from 2½ to 3 feet, east of the Cascades. The storm being followed by low temperatures in the valley of the Columbia, so blocked that river by ice above the mouth of the Willamette as to prevent any navigation until after the 12th. Below the Willamette, navigation was seriously interfered with for several days by an ice-gorge on Willow bar, four miles long. From Utah, the area moved rapidly eastward with decreasing pressure, and was central the afternoon of the 4th, in the Lower Missouri Valley; Omaha barometer 0.77 below the normal. At that observation, warm (the highest temperatures of the month) southerly winds, with rain, prevailed in the east and south quadrants of this area while an abnormal barometric fall of 0.33 inch in the past eight hours was reported from Des Moines and a maximum temperature from Leavenworth of 59°. At the same time in the northwest quadrant, high area No. II. was rapidly advancing, its progress marked by high N.W. winds with snow, and temperatures below zero in Southern Dakota (Deadwood, −11°).

At midnight on the 4th, barometric low area No. II. had moved rapidly northeastward to the Upper Mississippi Valley, with abnormal barometric falls in eight hours of 0.28 at Davenport and 0.29 at Milwaukee, while the following high area caused an abnormal rise of 0.31 at Omaha and 0.35 at North Platte and a fall of 39° in temperature at Leavenworth during the same time. Consequent upon such rapid changes, numerous tornadoes occurred on the 4th in Southwest Missouri. They are elsewhere described under the head of *Local Storms.* On the morning of the 5th, the area was central, with greatly decreased pressure in Northern Michigan; Escanaba barometer 28.92 or 1.09 below the normal. At that time the storm over the Upper Lake region (in connection with high area No. II.) was unusually severe; maximum wind velocity at Milwaukee S.W. 53 miles, and Duluth N.W. 47 miles. As navigation had practically closed in the Lake region, few or no disasters occurred to shipping on the Lakes. On that day, in connection with these areas, the maximum wind velocities, the lowest barometric pressures, and highest temperatures of the month occurred at nearly every station in the Lake region, the Ohio, Lower Missouri, and Upper Mississippi Valleys. Moving rapidly northeastward down the Valley of the Saint Lawrence, it had reached, with increasing pressure and diminishing violence, by the afternoon of the 6th, its northeastern limits. Signals were displayed for this area in the Lake region during the 4th and 5th, and along the Atlantic coast northward of Macon during the 5th. These signals were justified with but few exceptions, though ordered somewhat late for Lake Ontario, the North Carolina, and Maine coasts. The following are the highest wind velocities reported: Cape Henry, S.W. 27; Eastport,

S.E. 28; Barnegat, S. 34; Buffalo, W. 41; Sandusky, S.W. 41; Port Huron, S.W. 42; Duluth, N.W. 47; Milwaukee, S.W. 53.

No. IV. appears to have sprung up from the remains of No. III. As that area moved down the valley of the Saint Lawrence on the morning of the 6th, the pressure fell in North Carolina; Kittyhawk barometer that afternoon, 0.37 below the normal. The track of the area is uncertain, but it probably moved northeastward to the Banks of Newfoundland in a course nearly parallel with the coast. The lowest pressure noted was at Sydney, C. B., the afternoon of the 7th, 29.39 or 0.54 below the normal. Cautionary signals were displayed during the 6th and 7th, from Cape Henry to Cape Hatteras. A wind velocity of 40 N.W. was reported from the first-named station.

No. V. first appeared the morning of the 7th, in Nebraska, and, moving rapidly eastward, was central in Iowa at midnight; Des Moines barometer 0.18 below the normal. It moved thence with great rapidity and diminishing pressure to Georgian Bay; Parry Sound barometer A.M. of the 8th, 0.33 below the normal; it then followed an eastern course to the Atlantic Ocean, and was south of Newfoundland on the morning of the 9th. Its centre was followed by strong westerly gales, with snow in the Lake region. Signals were displayed in the Lower Lake region from midnight of the 6th to midnight of the 7th and were fully justified. Erie, S.W. 28 miles, and Rochester, W. 31.

No. VI. apparently developed in Manitobia during the 10th, and moving southeastward, was in Minnesota the morning of the 11th. Moving eastwardly with diminished pressure, it was in Ontario at midnight of the 12th; Saugeen barometer 0.49 below the normal. It passed thence northeastward through the Canadian maritime provinces to the Gulf of Saint Lawrence. Cautionary signals were ordered for all the lakes except Ontario, but were not justified, although velocities above 20 miles were reported from nearly every station.

No. VII. was apparently central to the northward of Fort Buford at midnight of the 12th; moving southeastward with rapidly decreasing pressure, it was central the morning of the 14th over Lake Michigan; Escanaba barometer 0.67 and Grand Haven barometer 0.68 below the normal. It then passed northeastward to the Gulf of Saint Lawrence (closely following the path of No. VI.) which it reached the morning of the 16th. The pressure remained very low over the maritime provinces from the 16th until the 19th; Sydney barometer at the P.M. report of the latter date 0.74 below the normal, after which the pressure rapidly increased. Cautionary signals were displayed in the Lower Lake region during the 14th, and were justified by the velocities: Port Huron, W. 25; Sandusky, S.W. 29; Buffalo, S.W. 30. The signal displayed at Eastport on the 15th was also justified by a velocity of E. 36 miles.

No. XV. appeared on the Oregon coast during the 26th; Roseburg barometer the morning of the 27th, 0.37 below the normal. Its move-

ment thence was very rapid, and, though decidedly abnormal, was very similar to that of low area No. XIII. of this month and No. XV. of December, 1877. Its centre was apparently that afternoon (27th) in Southwestern Idaho, at midnight in Utah, and on the following morning in Western Texas; Stockton barometer at last report, 0.34 below the normal. On the afternoon of the 28th the lowest pressure was in the Rio Grande Valley 0.32 below the normal. It moved thence eastward across the Gulf of Mexico, and passing over Northern Florida followed, during the 29th, a northeasterly path, nearly parallel with, and at some distance from, the Atlantic coast. The lowest pressure noted on that day was at Cape Lookout, P.M., barometer 0.50 below the normal. Off-shore signals were displayed on the Texas coast from the 26th to the 29th, and cautionary signals in the Eastern Gulf and along the Atlantic coast as far north as Delaware Breakwater on the 28th and 29th. Cautionary signals were also displayed from Cape May northward to Eastport from the afternoon of the 29th to the morning of the 30th. These signals were fully justified by the following maximum velocities: Macon and Cape Lookout, N.W. 32 miles; Pensacola, N. 40; Wood's Holl, N.W. 43; Thatcher's Island, W. 42; Indianola, N. 51; Cape May, N. 52.

TEMPERATURE OF THE AIR.

The mean temperature of the air for December, 1880, is indicated by isotherms on the Chart. The mean in every district east of the Rocky Mountains has been below the normal. Over the country to the westward, the temperature has been slightly above the normal, except at Portland, Oreg., where a deficiency of 2.2° prevailed. The temperature has been deficient 5° or more over the entire Missouri, Ohio, and Upper Mississippi Valleys, the Lake region (except northeastern New York), the Middle States, Tennessee, and North Carolina. From the Upper Missouri Valley deficiencies are reported, ranging from 10.5° at Bismarck to 13.5° at Fort Buford, and 18° at Fort Shaw. During the past ten years, lower mean temperatures during December occurred generally east of the Missouri Valley in 1872 and 1876; also in 1878 over the Gulf States, and in 1879 over the Missouri Valley. At Baltimore and Washington alone, the lowest mean temperatures of the past decade occurred. The following deviations at detached stations, not included in the districts, are noted: Mount Washington, 0.3°; Pike's Peak, +1.5°; Key West, 2.9°; Punta Rassa, 2.0°. The following are extracts from reports of voluntary observers: *Kansas:* Lawrence, mean 3.05° below that of the past twelve years. Holton, month unusually cold. *Maine:* Gardiner, month remarkable, not for its extreme cold, but for its uniformity of temperature; mean temperature for past forty-five years, 22.10°, for December, 1880, 0.25° below. *Maryland:* Fallston, mean lowest in past ten years, except December, 1876. *Nebraska*: Genoa,

month very cold. *New Hampshire:* Lake Village, Lake Winnepiseogee closed by ice on the 24th; one to two weeks earlier than usual. Contookville, mean, 2° below that of ten years. *New Jersey:* Newark, mean, 7.2° below the average of 35 years; the last decade of the month lower by 12° than such average. *New York:* North Volney, mean, 4.85° below that of December for past ten years. Friendship, coldest weather for years. Hector, month unusually cold. *Ohio:* Hudson, month remarkably cold. *Pennsylvania:* Wellsboro, mean lowest for past ten years; during the last four days of the month the temperature ranged lower than in any preceding December for twenty years. *Virginia:* Dover Mines, mean 13.1° lower than in 1879; Wyethville, month very cold. *West Virginia:* Helvetia, coldest in five years. Wellsburg, coldest for many years.

Frost.—Frosts were usually frequent and severe. Those in the Gulf States from the 9th to the 12th and from the 25th to the 31st were exceedingly severe, that of the end of the month injuring vegetation in Texas even to the mouth of the Rio Grande, and on the Florida coast to near Punta Rassa. The only sections not visited by frost were Southern Florida and the extreme southwestern portion of Arizona; certain sheltered stations in Southern California also escaped it.

PRECIPITATION.

The general distribution of rain-fall (including melted snow) for December, 1880, is shown on the Chart, from the reports of over 500 stations. The region of greatest rain-fall included the Pacific slope northward of Central California; on the Atlantic slope the rain-fall was heaviest along the coast of New Jersey, Delaware, and Virginia. In New England the rain-fall continued deficient, except in Maine and Connecticut. The excess in the Middle States was very marked on the coast, and gradually diminished toward the interior. In the South Atlantic States the rain-fall was especially local; the departures from the means of various stations being: Jacksonville, 1.90 inches; Charleston, 2.48; Cape Lookout, 5.04; Kittyhawk, +0.93; Charleston, +4.52. In the Gulf States the deficiency was general (except an excess in Eastern Alabama) and well distributed, with the peculiarity, however, of an excess of 1.67 at New Orleans; over Eastern Texas and Western Louisiana the departures ranged from 2.83 inches at Shreveport to 3.50 at Indianola, and 3.60 at Corsicana. In the Ohio Valley and Tennessee the deficiency was general, with an excess at one station (Cincinnati) of 0.51 inch. In the Lake region the greatest deficiencies occurred in the neighborhood of Lake Erie and the southwest part of Lake Michigan. The deficiencies in the Upper Mississippi and Lower Missouri Valleys were well distributed. Over the region of least rain-fall, Kansas, and Nebraska, probably not more than one-quarter of the usual amount fell. The excess on

the Pacific slope amounted at San Diego to 1.80, at San Francisco to 7.64, and at Portland, Oreg., to 7.69 inches. At Bainbridge Island, Wash. Ter., the month's rain-fall was the greatest ever recorded (twenty years' record), being 17.25 inches, which is 3.55 larger than that of March, 1875.

Rainy days.—Rain (or melted snow) to the amount of 0.01 inch has fallen on an unusual number of days in the country at large. Such days generally numbered from 18 to 22 in the Lake region and Ohio Valley elsewhere from the Mississippi Valley eastward from 12 to 18. On the Pacific coast from 10 to 14 in Southern California, and 20 to 24 elsewhere. The stations reporting the smallest number of such days were Denver, Dodge City, and Yuma, 2; Eagle Pass and Cheyenne, 4.

Cloudy days.—The month has been marked by extreme cloudiness from the Mississippi Valley eastward. The number of such days has generally varied in the Atlantic and Gulf States from 10 to 14; in Tennessee, the Ohio, and Upper Mississippi Valleys, from 14 to 18, and in the Lake region from 20 to 25. Regarding this the following extracts from Signal Service observers are noted: Little Rock, 2d, "sun seen for the first time since November 23d." Chicago, 27th, "sun first seen since the 14th." Detroit, 27th, "unbroken cloudiness since the 11th." Cleveland, 24th, "unbroken cloudiness since the 15th." Springfield, Ill., 24th, "eighth day without sunshine." Wellsboro, Pa., general cloudiness prevailed for 26 days—largest number reported. Buffalo, Oswego, and Rochester each report 25 cloudy days. From Denver but one and from Yuma but two cloudy day reported. On the Pacific slope from San Francisco northward, cloudiness prevailed from 20 to 25 days.

Rain or snow from a cloudless sky.—Oregon, Mo., 12th; Cincinnati, 10th; Burlington, Vt., 10th; Springfield, Ill., 29th; Bangor, Me., 29th.

Snow has fallen almost daily from the 6th in New England, the Lake egion, and Upper Mississippi Valley, and from the 18th in the Ohio and Missouri Valleys and the Middle States; on the 20th, 21st, 26th, and 29th, in the South Atlantic States; on the 19th, 20th, 22d, 28th, 29th, and 31st in the Gulf States; from the 2d, to 5th, 8th, 24th, 28th, and 29th, North Pacific region. The snow-fall in the Northwest districts, though frequent, was much lighter than usual. In the Atlantic States from Connecticut to the northern half of North Carolina the snow-falls were usually large, ranging from 2 to 3 feet. The following special cases are noted: 28th, Green Springs, Ala., 7 inches; Okalooska, La., 1 inch; 29th, Forsyth, Ga., heaviest fall since 1856; Atlanta, "one of the heaviest ever known;" Mobile: Montgomery, "5 inches, very remarkable, heaviest ever known;" Columbus, Ga., 4½ inches, "heaviest on record;" Augusta, Ga., "heaviest fall since 1857;" 30th, New Orleans; El Paso, Tex.; Rockport, Tex., 3 inches; 31st, Brownsville, Tex.; Fort Ringgold, Tex., 2 inches; Rio Grande City, 1.7 inches, first snow since December, 1866.

RELATIVE HUMIDITY.

The relative humidity, not corrected for elevation, in the Atlantic and Gulf States, Tennessee, the Mississippi, Ohio, and Lower Missouri Valleys has generally ranged from 70 to 75 per cent; in the Lake regions, from 76 to 83 per cent; in Northern California, from 81 to 88 per cent; in the Plateau district, from 56 to 78, and Rocky Mountain districts, from 49 to 63. The following percentages are noted as of interest: Cheyenne, 49; Pike's Peak, 61; Mount Washington, 79; Indianola, 81; Cleveland, Escanaba, and Grand Haven, 83; Duluth and Sacramento, 88; Bismarck, 89; Saint Vincent, 91, and Chincoteague, 93.

WINDS.

The prevailing winds during December, 1880, at Signal Service stations are shown on the Chart by arrows which fly with the wind. Northwesterly winds have prevailed in New England, Tennessee, the Middle and Gulf States, and from the Mississippi Valley westward to the Rocky Mountains. In the Lake region and the Ohio Valley the winds were southwesterly. In other districts they were variable.

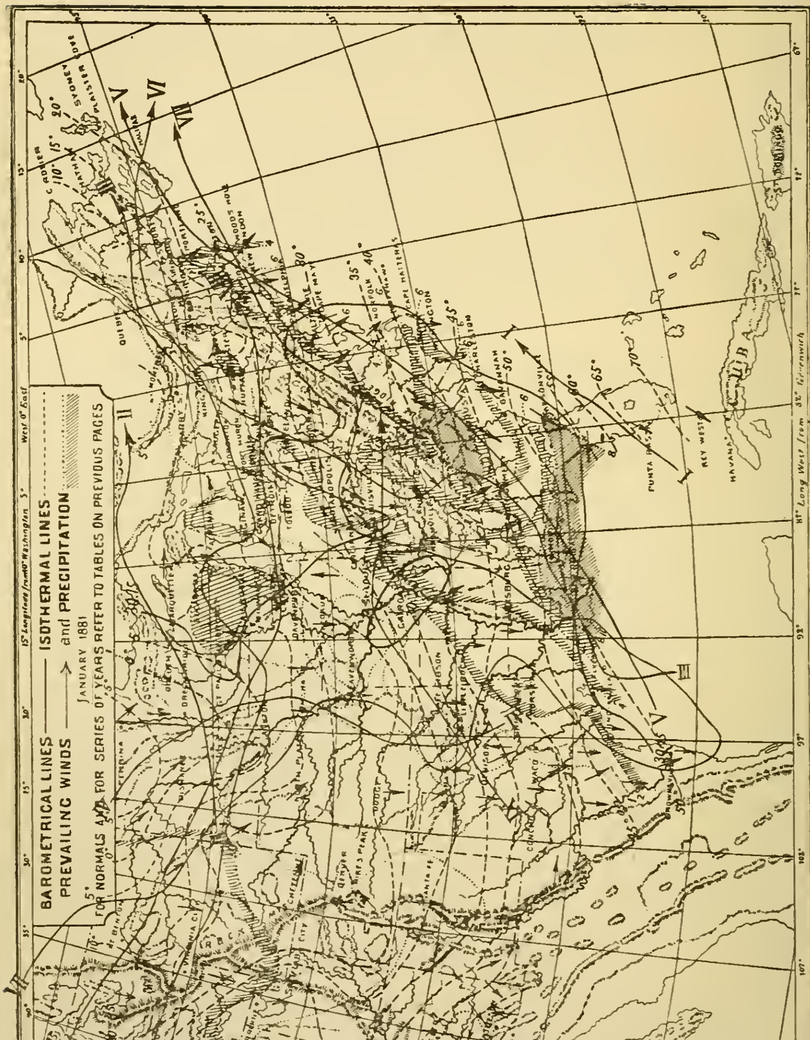
Local storms.—The following tornadoes on the 4th were reported by the Missouri weather service and the voluntary observers of the Signal Service in that section. Between the hours of 7 and 8 P.M., three comparatively violent tornadoes, pursuing nearly parallel paths to the northeastward, occurred in Southwestern Missouri in connection with the passage of low pressure area No. III. The track of the one farthest north passed near the towns of Sarcoxie, Lawrenceburg, and Ash Grove, destroying five buildings and causing much damage to other property. The second storm, passing near Pierce City, visited the towns of Verona, Brookline, Springfield, and Marshfield. The third storm passed through portions of Barry, Stone, Christian, and Webster Counties, visiting the town of Ozark. Several buildings were wrecked and considerable damage done.

ATMOSPHERIC ELECTRICITY.

Thunder-storms were frequent in Iowa, Missouri, Tennessee, and the Ohio Valley on the 4th and 5th, and the Gulf States from the 16th to the 19th; elsewhere, few or none were reported.

Atmospheric electricity interfering with telegraphic communications.—Silver City, N. Mex., 29th, Bismarck, 28th, very strong currents on wires in all directions. Fort Bennett, Dak., 29th, on wires in all directions.

Auroras.—The remarkable cloudiness of the month in the northern part of the United States prevented the display of auroras even if they had occurred. At Saint Vincent, Minn., however, auroras were observed on eight out of the eighteen evenings on which cloudiness did not prevail.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
JANUARY 1881
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES

7. MONTHLY WEATHER REVIEW, JANUARY, 1881.

BAROMETRIC PRESSURE.

The isobarometric lines on the Chart show the mean pressure for the month of January, 1881. Compared with the chart of the preceding review, it will be seen that the area of mean high barometer has advanced east towards the Atlantic coast, at least within the limits of the United States, while the area of mean low barometer remained central in the North Atlantic. This easterly movement has been more in the form of an extension of the high area of last month towards the east, as the centre of greatest pressure remains in the Mississippi Valley, where the mean barometer for the month is slightly below that of the preceding month. The most marked change in the mean monthly pressure occurred on the Pacific coast. The area of mean low barometer, central in the North Pacific last month, and including Washington Territory and Oregon in the southeastern quadrant, with a pressure of 29.88, has been replaced by a mean pressure of 30.08 at Olympia and 30.14 at Portland, and a general increase of pressure at all stations on the coast. Compared with January of last year it will be observed that the distribution of pressure was strikingly different in the two months. The pressure during January, 1880, was greatest on the Atlantic coast, with an area of low pressure near the centre of the continent, and this was accompanied by the highest mean temperature observed for many years at northern stations, while the reverse obtains during the January of 1881, both as regards pressure and temperature.

Departures from normal values for the month.—The pressure has generally averaged from 0.02 to 0.08 inch above the normal, except in the Gulf and South Atlantic States, where it has averaged from 0.02 to 0.05 inch below the mean for many years. The greatest departures are observed on the Pacific coast, being at Olympia 0.16 inch above. At San Francisco and San Diego the pressure ranged from 0.03 to 0.04 inch above.

Barometric ranges.—The barometric range during the month increases with the latitude on the Atlantic coast from 0.45 inch at Key West to 1.42 inches at New York. From New York northward the range decreases to 1.01 at Portland, and 1.04 at Eastport. Following the Mississippi Valley, the range increases from 0.76 at New Orleans to 1.33 at Cario, and thence northward it decreases to 1.14 at Saint Paul, 1.13 at Saint Vincent, and 1.05 at Duluth. The range increases with the latitude on the Pacific coast from 0.48 at San Diego, 0.63 at San

Francisco, 1.45 at Olympia, and 1.56 at Umatilla. The greatest ranges reported are: 1.58 at North Platte, 1.56 at Fort Buford, 1.45 at Sandusky, and 1.49 at Philadelphia. The smallest are: 0.36 at Tucson, 0.45 at Key West, 0.52 at La Mesilla, and 0.60 at Santa Fé.

Areas of high barometer.—Eight of these areas have passed over the districts east of the Rocky Mountains during the month, and two extended periods of high pressure occurred on the Pacific coast; the first extending from the opening of the month until the storm of the 10th, and the other from the 16th until the 24th. High areas Nos. II., III., and V. appear to have formed east of the Rocky Mountains, as a part of the permanent areas above referred to, previous to their advance as separate areas of high pressure. The course of these areas over the northern districts has caused a marked increase in the mean pressure for the month in these districts. Generally they were first observed in the extreme Northwest, or in the Saskatchewan region, and thence moved first to the southeast and then to the east, over latitudes north of the mean latitude of the centres of such areas.

Areas of low barometer.—Nine areas of low barometer appeared within the limits of the stations of the Signal Service during the month, three of which (Nos. I., III., and V.) originated south of the 30th parallel of latitude. Three probably originated in the North Pacific and three (Nos. II., IV., and IX.) were first observed on the eastern slope of the Rocky Mountains. No. IX. was preceded by violent storms and heavy rains on the Pacific coast, and reports from mountain stations indicate that a slight depression crossed the Rocky Mountains south of Salt Lake on the 30th.

No. V.—The gradual fall of the barometer over the region of the Gulf, and the heavy rains in Florida on the 8th, indicated the development of a low area in that region. High winds were reported from Key West and Cedar Keys on the night of the 7th, resulting from a slight depression, which disappeared during the day, leaving the barometer low over the Gulf, with conditions indicating the speedy development of a severe storm. The centre of disturbance appeared to be in the West Gulf, to the south of Galveston, during the 9th, the wind reaching a velocity of 42 miles from the north at Indianola, and 28 miles from the northeast at Galveston. Heavy rain occurred at stations on the Gulf coast during the day, and by midnight rain or snow was reported from all districts east of the Mississippi. The barometer fell rapidly during the night, and the advance of the high area from the northwest was accompanied by a rapid transfer of the centre of disturbance from near Mobile, Ala., to the Middle Atlantic coast during the eight hours following the midnight report of the 9th. The pressure continued low in the South Atlantic States, with variable winds on the morning of the 10th, but during the day the winds shifted to the north and west, with a decided fall in temperature and increased pressure, and by the morn-

ing of the 11th the centre moved to the northeast over the New England coast, causing violent northeasterly gales and very heavy rains at stations located near the track of the centre of greatest depression. The region of snow extended from Texas northeast to New England, where trains were delayed several hours during the 10th and 11th. Many observers located in the northeastern section of the country reported this as the severest storm of the season. At Bellows Falls, Vt., nearly three feet of snow reported. The observer at Portsmouth, N.H., reports storm outside of harbor particularly severe, large fleet of vessels in harbor. Toronto observer reports heavy snow-storm throughout Ontario. The British brig Happy Return went ashore near Nantucket beacon; total loss. A violent southeast storm occurred at Provincetown, Mass., causing some damage to shipping on the 10th. Voluntary observers throughout New England report from 12 to 18 inches of snow.

No. IX.—This storm is marked on the Chart as first central in Northern Texas at midnight of the 30th, but it is probable that it passed from the Pacific coast, or that its development was due to the heavy rain in that region on the previous day. The course of the centre after its first appearance was to the northeast until the centre reached the Ohio Valley as a well-defined storm, accompanied by a very heavy rain near the central area, which, at that time, was marked by a small elliptical isobar of 29.80, central near Louisville at the 11 P.M. report of the 31st. The succeeding reports show that the direction of the area changed slightly on the following day, and that it passed off the South Atlantic coast; causing dangerous winds as far north as Boston.

TEMPERATURE OF THE AIR.

The mean temperature of the air for January, 1881, is shown by the isothermal lines for the month on the Chart. The average temperature of the month has been below the normal in all districts east of the Rocky Mountains, and also in the southern districts on the Pacific coast, where it has averaged from 1.3° to 2.5° below. The greatest departures occurred in Texas, and northward to British America, and northeastward over the Lake region, where the temperature has ranged from 6.5° to 9.0° below the normal of the month. On the Pacific coast the temperature has averaged 3.5°, above the normal in the central districts, about normal in the northern districts, and 3.5° above in the region of Salt Lake. The departure from the normal temperature has been greater than during the preceding month, which was the coldest, as compared with records of previous years, since the establishment of the Signal Service. This month has been the coldest ever observed in the northern and eastern districts, excepting that of January, 1875; while in the Southern States, east of the Mississippi, the only years showing a lower temperature were those of 1872 and 1873. At Washington, D. C., the average tempera-

ture was lower than that of any preceding January of which this office has any reliable record.

PRECIPITATION.

The distribution of rain-fall for January, 1881, is shown on the Chart, as determined from the regular Signal Service stations and about 450 reports of army post surgeons and voluntary observers. The table on the chart shows the average precipitation for each district as compared with that of the present month. An excess of rain or snow-fall has occurred in the districts on the Atlantic and East Gulf coasts, varying from 3.80 inches in Florida to 0.83 inch in New England. In the Middle and North Pacific coast region the excess has ranged from 2.61 to 2.16, while the greatest deficiency is reported from the South Pacifie coast region, where it amounts to 1.26 inches. In Missouri, Tennessee, and Ohio Valley and the Lower Lake region, the amount rain and snow-fall has been from one-half to one inch less than the average for the month, and in all other districts not previously named there has been a slight excess, except, possibly, the region lying south of the Platte over and north of Texas. In this region the stations are so limited in number that it is not possible to give full and accurate information, but the indications are that the rain-fall has been very slight in this region.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 7 to 18; Middle Atlantic States, 11 to 16; South Atlantic States, 10 to 18; Eastern Gulf States, 11 to 16; Western Gulf States, 6 to 13; Ohio Valley and Tennessee, 13 to 23; Lower Lake region, 10 to 24; Upper Lake region, 10 to 20; Upper Mississippi Valley, 3 to 18; Missouri Valley, 8 to 17; Valley of the Red River of the North, 6 to 11; Texas, 3 to 13; Rocky Mountains, 1 to 12; Middle Plateau, 6 to 18; Southern Plateau, 0 to 3; California, 3 to 11; Oregon, 10 to 19; Washington Territory, 12 to 19.

Cloudy days.—The number varied in New England from 3 to 16; Middle Atlantic States, 10 to 16; South Atlantic States, 13 to 20; Eastern Gulf States, 8 to 21; Western Gulf States, 9 to 16; Ohio Valley and Tennessee, 14 to 22; Lower Lake region, 15 to 25; Upper Lake region, 6 to 18; Upper Mississippi Valley, 9 to 17; Missouri Valley, 7 to 15; Valley of the Red River of the North, 4 to 6; Texas, 2 to 21; Rocky Mountains, 1 to 21; Middle Plateau, 10 to 16; Southern Plateau, 2 to 5; California, 5 to 10; Oregon, 12 to 19.

Rain or snow from a cloudless sky.—Leavenworth, 21st; Omaha, 21st, 22d; Cincinnati, 27th; Lewiston, Idaho, 28th; Burlington, Vt., 30th.

Snow was reported in the various districts on the following days: New England—3d to 12th, 14th, 17th, 18th, 19th, 21st, 22d, 26th to 31st. Middle States—1st to 6th, 9th to 12th, 14th, 16th, 19th, 21st to 31st. South Atlantic States (except Southern Georgia)—1st to 3d, 24th,

25th. East Gulf States (except Florida)—1st, 2d, 23d, 24th. West Gulf States (including Texas)—1st to 3d, 5th, 8th to 11th, 17th, 19th, 20th, 22d to 24th; at New Orleans 4 inches fell on the 24th, being the greatest depth since 1852, when sleighing was indulged in; Melissa, Tex., "have had so far seven snow-storms this winter, which is five more than has ever occurred in any past winter, but frequently one storm has given a greater depth than the combined storms of this season." Tennessee—1st, 2d, 4th, 5th, 6th, 9th to 14th, 21st to 26th. Ohio Valley—3d to 19th, 21st to 31st. Lower Lakes—3d to 17th, 21st to 31st. Upper Lakes—1st to 16th, 20th to 31st. Upper Mississippi Valley—4th to 9th, 13th to 16th, 20th to 31st. Missouri Valley—1st to 16th, 20th to 31st. Red River of the North Valley—1st, 5th, 7th, 8th, 9th, 12th to 15th, 29th to 31st. Rocky Mountains—1st to 17th, 20th to 31st. Southern Plateau—2d, 3d, 4th, 6th, 14th, 16th, 17th, 18th, 20th, 30th. Middle Plateau—1st, 4th to 11th, 13th to 16th, 25th, 26th. Northern Plateau—3d, 4th, 7th, 9th, 10th, 16th, 19th, 26th. California—9th, 10th, 13th, 15th, 16th, 17th, 19th, 25th, 26th. Oregon and Washington—2d, 3d, 9th to 15th, 17th, 24th to 28th, 31st.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, 64 to 75; Middle Atlantic States, 70 to 84; South Atlantic States, 71 to 85; Eastern Gulf States, 73 to 81; Western Gulf States, 64 to 82; Ohio Valley and Tennessee, 69 to 80; Lower Lake region, 66 to 83; Upper Lake region, 68 to 81; Upper Mississippi Valley, 71 to 77; Missouri Valley, 71 to 92; Valley of the Red River of the North, 69 to 93; Texas, 52 to 77; Middle Plateau, 48 to 64; Southern Plateau, 39 to 47: California, 63 to 82; Oregon, 78 to 87. High stations report the following percentages, not corrected for altitude: Mount Washington, 74.2; Pike's Peak, 69.8; Denver, 58.5; Cheyenne, 57.5; Eagle Rock, 77.7; Santa Fé, 60.0.

WINDS.

The prevailing direction of the wind during the month of January, 1881, is shown by the arrows flying with the wind on the Chart. The prevailing direction was northwest to north on the Atlantic coast, in the Southern States, and at stations on the eastern slope of the Rocky Mountains. North to east winds prevailed in California and Arizona, and east to south winds in the North Pacific coast region, and at stations in Nevada and Idaho. In the Lake region the prevailing direction was from northwest to southwest, except in the eastern portion, where it was generally from the south. The prevailing direction of wind at Pike's Peak and Denver was from the southwest and south respectively. The prevailing direction on Mount Washington was northwest.

High winds.—Winds of 50 miles and above were observed as follows: On summit of Mount Washington, 1st to 10th, 12th to 15th, 17th, 18th, 20th to 31st; the highest wind was 130 miles S. on the 10th and N.W. on 29th. On summit of Pike's Peak, 4th, 9th to 12th, 26th to 30th, with a maximum of S.W. 88 miles on the 28th. Umatilla, N.E. 58 on the 26th. Cheyenne, W. 52, 11th. North Platte, N. 52, 5th. Fort Elliott, N.W. 52, 5th. Kittyhawk, N. 56, 14th. Delaware Breakwater, N. 52, 14th. Cape May, N.W. 56, 27th. Wood's Holl, S.E. 56, 10th. Thatcher's Island, E. 66, 21st. New Shoreham, N.E. 60, 21st.

Local storms.—Santa Anna Valley, Cal., 21st, P.M., violent wind-storm, destroying buildings and fences, delaying trains, and prostrating telegraph poles. Petersburg, Va., 19th, very heavy wind-storm; large warehouse destroyed, and other property more or less damaged.

Droughts.—Springfield, Ill., 20th, wells and cisterns drying up; 31st, river so low that it has become nearly stagnant, and gives forth a bad odor; farmers have been hauling water from city for past two weeks; drought has been general and very severe in the central portion of the State. Peoria, Ill., 25th, much suffering from want of water. Holton, Kans., 31st, month remarkably dry. Lawrence, Kans., 31st, very dry; rain-fall 0.99 inches below the average for the past thirteen years. Yates Centre, Kans., 31st, dryest within the memory of the oldest settler; streams and wells very low; stock driven three miles for water. Creswell, Kans., 31st, wells and springs almost exhausted. Missouri weather service reports a monthly rain-fall at the central station of 0.39 inches, the smallest recorded since 1837; lowest previous rain-fall was 0.41 inch in 1857, and only twice since 1839 has the January rain-fall been less than 0.50 inch. Mendon, Mass., 31st, much need of rain; wells and cisterns dry. Auburn, N. H., 31st, wells and cisterns dry in many localities. Woodstock, Vt., 31st, drought throughout month, and still continues without abatement; but two families in the city have sufficient water for household purposes; farmers compelled to haul water for stock from long distances.

ATMOSPHERIC ELECTRICITY.

Auroras.—Faint auroral displays were observed at Saint Vincent, Minn. (the most northerly of Signal Service stations), on the 2d, 21st, 22d, 23d, 24th, 26th, and 29th. With these exceptions, no display was observed outside New England or south of the 42d parallel save that of the 31st.

Atmospheric electricity interfering with telegraphic communication.—Accompanying a very severe snow-storm of the 6th, which prevailed over a space of about 800 miles in width along the line of the Union Pacific Railroad, between Omaha and Ogden, there was experienced a very positive display of electrical disturbance. For twenty-four hours the tele-

graph wires were rendered useless, the intensity being shown by the fact that when the telegraph key was opened, a steady electric light burned at the connecting points. According to the records kept by the chief operator of the Union Pacific Railroad telegraph lines there is but one exception in the past 12 years to the regular yearly occurrence of similar storms between the 5th and 7th of January. At Fort Apache, Ariz., on the 16th, wires could not be worked for a considerable time.

AMERICAN STORMS ADVANCING IN A SOUTHEASTERLY DIRECTION.[1]

Contributions to Meteorology, being Results derived from an Examination of the Observations of the United States Signal Service, and from other Sources; by Elias Loomis, Professor of Nat. Phil. in Yale College.

During the colder months of the years, storms while crossing the United States frequently advance, during a portion of their course, in a direction from northwest to southeast. This direction is not confined to any particular section of the country, but occurs most frequently in the region between the Rocky Mountains and the Mississippi River. This course is seldom maintained as far south as the parallel of 30°, and after reaching its most southerly point, the storm frequently changes its course towards the northeast. The following table shows those cases in which storms have advanced towards the southeast as far as the parallel of 28°. The first six columns describe each storm as long as its course continued southeasterly; the last column gives some indication of the subsequent course of each storm.

No.	Date.			Latitude. beg. end.	Longitude. beg. end.	Course.	Vel. miles.	Subsequent course.
				° °	° °			
1	1874.	Feb.	17.2–18.2.....	33–27	86–79	S.E.	21.8	Unknown.
2		Apr.	15.3–16.3.....	41–26	101–89	S.E.	21.1	Unknown.
3	1875.	Jan.	15.1–16.2.....	44–27	106–91	S.E.	27.1	Unknown.
4	1876.	Feb.	3.4.1.....	33–28	98-80	S.E.	28.4	Unknown.
5		Mch.	6.2–12.1.....	47–27	127–89	S.E.	15.7	Unknown.
6		May	6.3– 7.3.....	33–27	100–93	S.E.	25.0	Unknown.
7	1877.	Jan.	4.2– 5.3.....	46–?8	100–90	S.S.E.	40.4	N E.
8		Mch.	21.2–24.1.....	42–28	100–95	S.S.E.	22.5	N.E.
9		Dec.	19 –20 . ..	44–28	102–98	S.E.	10.0	N.
10		Dec.	22 –27.2.....	47–27	102–95	S.E.	29.7	N.E.
11	1878.	Feb.	1.1– 2.3.....	33–26	96–84	S.E.	18.3	N.E.
12		Aug.	20.2–24.2.....	38–22	83–81	S.S.E.	15.1	Became extinct.
13		Nov.	16.2-17.2.....	28–24	102–93	S.S.E.	24.0	N.E.
14	1879.	Jan.	6.3– 7.3....	38–17	110–98	S.E.	39.2	N.E.
15		Jan.	8.3–11.1.....	49–27	119–98	S.E.	30.4	N.E.
16		May	4.1– 6.1.....	34–24	101–96	S.S.E.	16.1	Became extinct.

We see from this table that the average velocity of these storms while pursuing their course toward the southeast, was twenty-four miles per hour, which differs but little from the average velocity of storms in other

[1] Read before the National Academy of Sciences, New York, Nov. 18th, 1881.

parts of the United States. The lowest latitude attained by any of these storms was 22½ degrees; and in only three cases did the low centre reach the parallel of 25 degrees. In eight cases the storm centre, after completing its course towards the southeast, changed its course and proceeded towards the north or northeast. In two of the remaining cases the intensity of the storm declined in advancing southward, and they apparently became extinct soon after the dates given in the table. The same was probably true in the six remaining cases, but the observations are not sufficient to establish this with certainty.

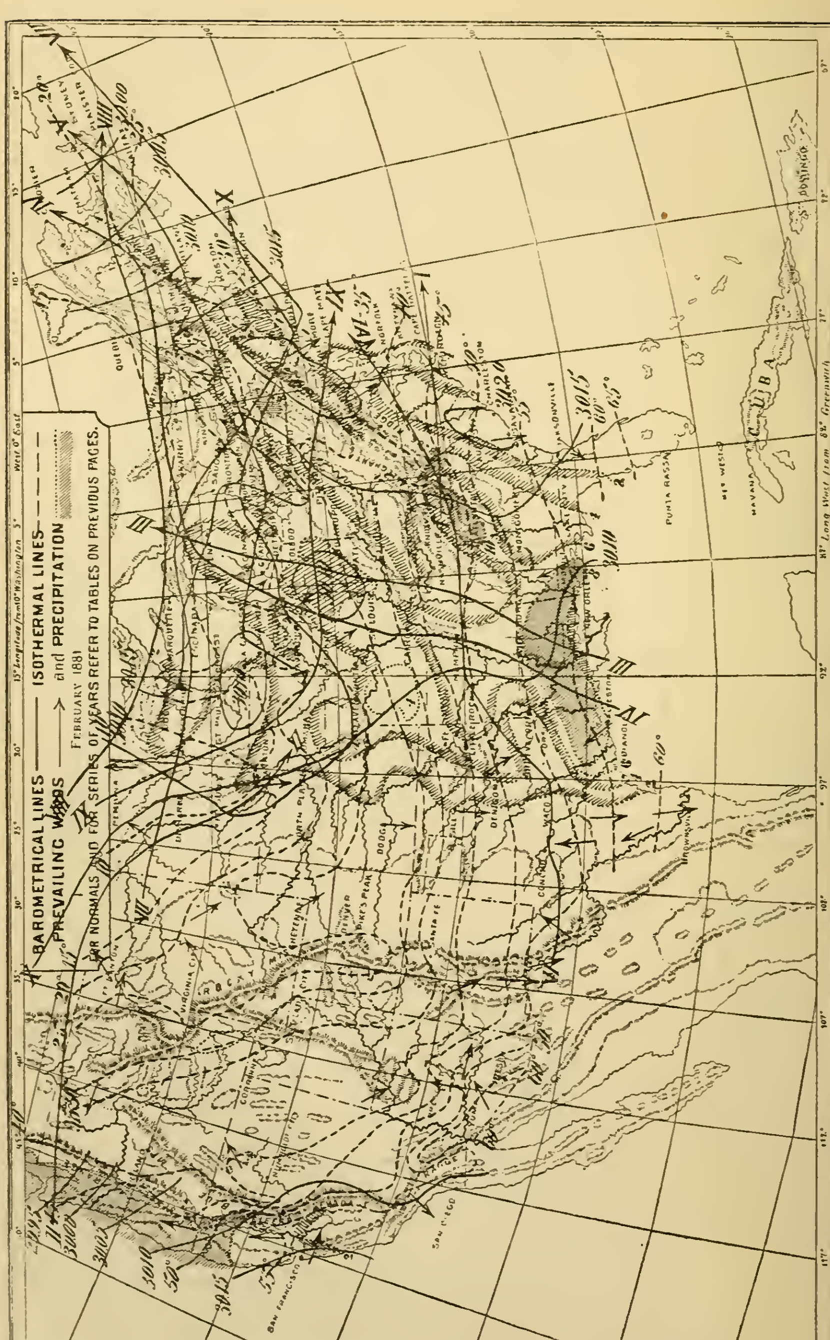
Storm No. 12 was quite peculiar, having pursued a path almost directly opposite to that of ordinary storms. During the afternoon of August 20th, 1878, there was an area of low pressure (29.75) over West Virginia, being part of a greater depression whose centre was over Newfoundland, and there was a slight tendency to the formation of an independent system of circulating winds. Owing to a slight increase of pressure on the north side, this low area was crowded southward, and in the afternoon of August 21st assumed the character of an independent low area (29.78) with a feeble system of circulating winds. At 7.35 A.M., August 22d, this low centre had been crowded south to latitude 30°, the greatest observed depression being now 29.88. After this the pressure increased, and the low centre could not be distinctly traced. This example appears to illustrate the general character of areas of low pressure, and shows that their progressive movement is not due to a simple drifting of the atmosphere, but rather to a diminution of pressure on one side of the low area and an increase of pressure on the other side. In the present case there was scarcely an appreciable diminution of pressure on the south side, and only a slight increase of pressure on the north side.

American storms advancing northerly and easterly.—The storms which cross the United States north of parallel 38°, generally pursue a course a little to the north of east; while those which come from the region south of latitude 38° generally pursue a course nearly northeast especially in the neighborhood of the Atlantic coast. During the summer months few storm-centres travel south of the parallel of 38°, and during this period the average course of storms is almost exactly towards the east.

The following table shows those cases in which storms have travelled northward and eastward, and came from a point as far south as latitude 26°. The arrangement of the table is similar to that of the preceding. Columns 3 and 4 show the position of the storm-centre at the beginning and end of the northeasterly motion, as far as indicated by the observations; column 7 shows the lowest pressure reported, and column 8 gives a brief indication of the previous course of the storm.

We see from this table that storms of this class occur most frequently in the autumn, and least frequently in summer. One of these storms began near latitude 20°; and seventeen of them began south of latitude 24°.

No.	Date.			Latitude. beg. end.	Long. beg. end.	Course.	Vel. miles.	Lowest barom.	Previous course.
				° °	° °				
1	1872.	Nov.	6.1– 7.3	26–47	95–65	E.N.E.	60.4	29.71	Unknown.
2		Nov.	7.3– 9.3	25–30	95–78	E.N.E.	21.1	29.74	Unknown.
3		Dec.	9.2–13.3	26–47	101–57	N.E.	28.6	29.86	Unknown.
4		Dec.	23.2–27.2	25–44	95–58	N.E.	29.8	29.17	Unknown.
5	1873.	Feb.	19.1–22.1	21–45	98–64	N.E.	35.1	29.17	Unknown.
6		May	4.1–10.1	24–43	98–81	N.E.	15.8	29.57	Unknown.
7		Sept.	18.1–20.1	24–34	92–94	N.E.	24.3	30 57	Unknown.
8		Sept.	22.3–24.1	25–36	86–72	N.E.	28.5	29.78	Unknown.
9		Oct.	5.1– 8.2	25–43	87–62	N.E.	32.9	29.02	Towards N.W.
10		Dec.	24.2–27.1	24–43	88–62	N.E.	30.4	29.37	Unknown.
11	1874.	Jan.	5.2– 9.1	25–49	87–68	N.N.E.	18.0	29.42	Unknown.
12		Feb.	7.2–11.1	25–46	82–58	N.N.E.	25.0	28.95	Towards N.W.
13		April	17.3–24.1	24–46	94–59	N. & N.E.	29.7	29.36	Unknown.
14		Sept.	2.3–10.2	22–50	99–89	North.	21.5	29.47	Unknown.
15		Sept.	27.1–30.2	25–59	87–66	N.N.E.	26.0	28.94	Unknown.
16		Dec.	18.2–21.1	25–39	96–62	N.E.	34.6	29.33	Unknown.
17	1875.	Nov.	6.1– 7.3	25–31	98–78	E.N.E.	32.9	30.82	Unknown.
18	1876.	Oct.	19.1–21.1	21–32	82–72	E.N.E.	19.5	29.51	Not traceable.
19	1877.	Sept.	16.1–21.3	25–31	96–76	E.N.E.	10.7	29.40	Unknown.
20	1878.	Jan.	6.1–12.2	24–46	100–56	N.E.	26.4	28.85	Not traceable.
21		Feb.	26.2–28.1	24–30	92–71	E.N.E.	31.1	29.71	Came from N.W.
22		Mch.	17.1–17.2	23–25	85–78	E.N.E.	?	29.79	Not traceable.
23		Mch.	19.3–22.3	25–27	95–78	East.	15.0	29.71	Came from W.
24		July	2.1– 2.3	25–27	85–78	E.N.E.	22.6	29.77	Not traceable.
25		Sept.	24 –33	15–32	76–61	N. & N.E.	10.1	29.70	Not traceable.
26		Oct.	21.1–24.2	20–38	81–57	N. & E.	27.5	28.83	Not traceable.
27		Nov.	13.3–20.1	22–44	97–57	E. & N.E.	24.5	29.83	Not traceable.
28		Nov.	17.2–21.1	24–47	93–57	N.E.	40.3	29.47	Came from N.W.
29	1879.	Nov.	19.1–20.3	23–49	74–60	N.N.E.	48.8	29.00	Not traceable.
30	1880.	Jan.	24 –28.1	21–36	86–75	North.	14.3	29.68	Not traceable.
31		Mch.	7.3– 9.2	26–32	99–74	E.N.E.	38.0	29.86	Not traceable.
32		May	3.1– 6.2	26–47	93–59	N.E.	23.8	29.79	Unknown.
33		Aug.	19 –20	20–27	78–74	N.N.E.	12.4	29.86	Towards N.W.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
FEBRUARY 1881
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES.

8. MONTHLY WEATHER REVIEW, FEBRUARY, 1881.

BAROMETRIC PRESSURE.

The mean pressure of the air over the United States and Canada for the month of February, 1881, is shown by isobars on the Chart. The eastward movement of the area of high barometer (noted in the last month's review) has been still more marked during the present month, the region of maximum pressures having been transferred from the Mississippi Valley to the Atlantic States, while the area of lowest barometer occupies the region covered by the maximum pressures of December, 1880. A glance at the Chart at once reveals the effect of this redistribution of pressure upon the prevailing direction of the wind in the Gulf States, Tennessee, the Ohio Valley, and Lake region. On the Pacific coast the highest pressures are over California, and the northerly winds along the coast would seem to indicate that the region of maximum barometer is over the ocean.

Departures from the normal values for the month.—The region of greatest departure from the normal covers Northeastern New York, Vermont, and New Hampshire, being + 0.15 at Albany and Mount Washington, and +0.16 at Burlington; along the New England coast it averages about + 0.13, while the line of + 0.10 runs from Cape May northwestward to Lake Superior. From this line of +0.10, in a southwesterly direction, it gradually decreases toward the line of no departure, which runs through Florida, Georgia, Northern Alabama, Tennessee, and Missouri. At Indianola the departure is −0.06 and at New Orleans −0.03. On the Pacific coast and in the Rocky Mountain region the departures are zero or quite small.

Barometric ranges.—The range of pressure during the month has varied in the extremes from 0.36 inch at Key West to 1.72 inches at Burlington, Vt. Ranges of 1.00 and above were reported from stations in Washington Territory, Montana, and Dakota, then southward to Brownsville, Tex., and northeastward over the remaining sections of the country to the Atlantic coast (except the East Gulf States), with but the variance of a single station, viz., Little Rock, Ark., 0.96. Throughout the territory included between the parallels of 30° and 47° and west of the 102d meridian, the range varies from 0.32 at San Diego to 0.95 at Umatilla. Along both the Atlantic and Pacific coasts the range increases with the latitude; along the southern boundary of the United States the range increases quite rapidly from both California and Florida inward to the maximum in Lower Texas. The smallest ranges occur at

the southern stations—Key West and San Diego; the largest in the Upper Lake region and New England.

Areas of high barometer.—Seven of these have been sufficiently marked to merit a brief description. The most remarkable was No. I., which occupied, in the last days of January, the Lake region, and continued in the same district until the 7th. It is, perhaps, due to this high area that the barometer for the month is generally above the mean east of the Mississippi River and the temperature below the mean for the same period. High areas Nos. IV. and V. should, for the Pacific coast, be regarded as a single high pressure. As usual, all the minimum temperatures of the month are associated with the high barometers.

No. V.—The barometer remained above the mean on the Pacific coast on the 18th and 19th, although the area of the highest pressure had to be transferred to Texas. On the 20th a slight rise took place in California, the barometer reading 30.4 at Red Bluff and at Sacramento. On the 21st the highest area moved eastward over the Northern Plateau. Maximum readings were reported at Roseburg of 30.48, or 0.41 above the normal, and at Boise City of 30.5 or 0.43 above the normal. On the 22d from Washington Territory to Dakota the barometer averaged more than 0.3 above the normal. On the 23d the area of highest pressure was rapidly transferred to the Northwest and thence to the Upper Lake region. On the 24th, with diminishing pressure, this high barometer disappeared in advance of low area No. IX. During the continuance of Nos. IV. and V. on the Pacific coast no rain fell from the afternoon of the 18th until the 25th in California, Nevada, Utah, and Arizona.

Areas of low barometer.—Ten such areas have had their tracks charted for the month of February, 1881. Of these, two—Nos. III. and IV.—appear to have been developed in the Gulf of Mexico. One only —No. II.—with a defined track within the limits of the chart crossed the Rocky Mountains from the Pacific coast, and this disappeared in the Lower Missouri during the régime of high area No. I. in the Lake region. Four—Nos. VII., VIII., IX., and X.—have their tracks first charted in the Northwest. Special attention is invited to the tracks of low areas Nos. III. and IV., which are abnormal; a comparison made with the charts of the storm tracks for the month of February in previous years shows that not since the establishment of the Weather Service have any storms pursued for this month so northerly a course. These storms were both severe, No. IV. being in some respects the most violent of the month. The great floods of February were all due to these two storms. The closest comparison is in February, 1874, when several low areas developing in the Southwest moved in a northeasterly track over the United States, but, as before stated, this office has no record of any storm tracks for February which pursued a course so nearly to the north. The maximum temperatures of the month are

generally associated with the progress of storm centre No. X. across the country.

No. III.—For several days before the 8th the barometer had been below the mean in the southwest, but with no well-defined centre of depression. On this day the greatest fall was at New Orleans, where, at the midnight observation, the barometer was 29.61, or 0.52 below the normal. On the 9th the centre of low area moved in a northerly direction into Indiana, the barometer at Indianoplis, 29.28, being 0.72 below the normal. On the 10th the centre of low area pursued its track to the north, but during the day there was a great fall in pressure over the Lower Lakes, Middle States, and New England. Very heavy rain, with consequent floods, was reported from the Southern States and the Ohio Valley. Cautionary signals for this storm were ordered on the 8th from Mobile to Cedar Keys, on the 9th from Jacksonville to Wilmington, and from Kittyhawk to Sandy Hook; these were generally justified by the following velocities: Mobile, 28 S.W.; Pensacola, 28 S.W.; Cedar Keys, 25 E.; Smithville, 28 S.E.; Kittyhawk, 32 S.; Chincoteague, 36 S.E.; Delaware Breakwater, 42 S.; Cape May, 39 S.E. Cautionary signals were ordered for Lake Michigan on the 9th, and were justified by the following velocities: Grand Haven, 32 N.W.; Milwaukee, 45 N.E.

No. IV.—After the passage of low area No. III. there was a sharp rise in pressure over the Lower Mississippi Valley, while along the Rio Grande the barometer continued very low. On the 10th the pressure in the Gulf began to yield in advance of low area No. IV., which was a secondary development in the Gulf of low area No. III.; its centre at the midnight report of the 10th was located in Western Louisiana. On the 11th, pursuing a track nearly parallel to No. III., its centre advanced into Illinois and Indiana, where the barometer was in genera three-fourths of an inch below the mean. On the 12th, still continuing its northerly direction, the centre of low barometer was at the afternoon observation near Alpena, where the pressure of 29.22 was 0.9 below the normal; the depression then changed its path to the eastward, traversing on the 13th the Saint Lawrence Valley and New England. The heaviest rains accompanying this storm occurred in New England. High northeast gales, with heavy snow, were reported from the Northwest and Upper Lakes, and after the passage of the centre of depression in the Ohio Valley and Lower Lakes a great fall occurred in temperature, accompanied by light snow and followed by clearing weather. Cautionary signals for this storm were ordered on the 10th from New Orleans to Pensacola, on the 11th from Smithville, N. C., to Thatcher's Island, and on the 12th at Portland and Eastport. The signals on Lake Michigan were continued from the previous storm. These signals were generally justified by the following maximum velocities: New Orleans, 28 N.W.; Mobile, 28 S.W.; Pensacola, 31 S.W.; Smithville, 34 S.W.; Wilmington, 30

S.W.; Macon, 33 S.W.; Hatteras, 40 W.; Kittyhawk, 42 S.; Cape Henry, 32 S.W.; Norfolk, 33 S.W.; Chincoteague, 40 S.E.; Delaware Breakwater, 58 S.; Cape May, 50 S.; Barnegat, 36 S.; Sandy Hook, 28 W.; New York, 32 S.E.; New London, 32 S.E.; New Shoreham, 40 W.; Newport, 39 W.; Wood's Holl, 48 W.; Boston, 35 W.; Thatcher's Island, 40 N.E.; Portland, 33 E.; Eastport, 40 S.E. On the 12th the cautionary signals were changed to cautionary off-shore signals from Smithville to Thatcher's Island, and were generally justified, both as to direction and as to velocity.

TEMPERATURE OF THE AIR.

Temperature of the air.—The mean temperature of the air for February, 1881, is shown by the isothermal lines on the Chart. Throughout the whole country of the east of the 107th meridian, includ'.g the northern Rocky Mountain slope, but excluding New England and the Florida peninsula, the temperature has been below the normal. In the two latter districts and in the Northern Plateau region it has experienced no change, while to the westward in the remaining districts the temperature has risen above the normal. The following large abnormal deviations may be noted: Fort Bennett, −14.7°; Omaha, −9.7°; Dodge City, − 9.0°; Leavenworth, − 7.9°; Yankton, − 7.2°; North Platte, −6.8°; Fort Gibson, −6.6°; Fort Sill, −6.2°; La Crosse, −4.5°

PRECIPITATION.

The general distribution of rain-fall (including melted snow) for February, 1881, is shown on the Chart from the reports of over 500 stations.

The regions of greatest rain-fall are to be found along the Pacific coast north of parallel 40°, in Northern Texas, Northern Illinois, in the Western Gulf States, and Western North Carolina. The region of no precipitation, covering a territory of about 200 miles square, embraces a portion of Southeastern California and Southwestern Arizona. As compared with the mean of past years, the rain-fall for the month is in general considerably above the average. The most marked departures occurred in the Middle and Northern Pacific coast regions, Lower Missouri Valley, Upper Lake region, Middle Atlantic States, and in the central portion of the Western Gulf States. Departures of excess at particular stations were most marked in these districts. In Southern Florida, Southern Dakota, and along the California coast south of parallel 40°, individual deficiencies were quite prominent. The rainfall of the Rocky Mountain and Plateau districts, nearly always comparatively low, was quite evenly distributed, except in a narrow region extending northward from Salt Lake City.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 9 to 18; Middle States, 10 to 15;

South Atlantic States, 7 to 12; Eastern Gulf States, 5 to 12; Western Gulf States, 10 to 12; Ohio Valley and Tennessee, 12 to 20; Lower Lake region, 15 to 22; Upper Lake region, 11 to 20; Upper Mississippi Valley, 10 to 18; Missouri Valley, 11 to 16; Valley of the Red River of the North, 12 to 19; Texas, 1 to 9; Rocky Mountains, 2 to 10; Middle Plateau, 3 to 16; Southern Plateau, 0 to 5; California, 3 to 14; Oregon, 6 to 14; Washington Territory, 7 to 19.

Cloudy days.—The number varied in New England from 2 to 13; Middle Atlantic States, 3 to 13; South Atlantic States, 5 to 13; Eastern Gulf States, 2 to 12; Western Gulf States, 8 to 12; Ohio Valley and Tennessee, 10 to 16; Lower Lake region, 12 to 19; Upper Lake region, 11 to 16; Upper Mississippi Valley, 12 to 15; Missouri Valley, 9 to 12; Valley of the Red River of the North, 10 to 12; Texas, 1 to 10; Rocky Mountains, 3 to 15; Middle Plateau, 8 to 19; Southern Plateau, 0 to 5; California, 2 to 12.

Rain or snow from a cloudless sky.—Colorado Springs, Colo., 17th.

Snow.—No precipitation of this nature was reported from the country to the south and east of the 35th parallel and the 104th meridian respectively, except in extreme Northern Texas on the 11th and 15th, and the extreme western portion on the 6th and 10th. In California none was reported except along the mountain ranges to the northeast of Los Angeles and east of Sacramento. In the various other districts snow fell on the following dates: New England, 1st to 5th, 11th to 28th; Middle States, 1st, 2d, 13th to 25th; Western North Carolina, 3d, 12th, 13th; Tennessee and the Ohio Valley, 1st to 5th, 12th to 28th; Lower Lake region, 1st to 5th, 8th, 9th, 12th to 28th; Upper Lake region, 1st to 28th; Upper Mississippi Valley, 1st to 28th; Missouri Valley, 1st, 2d, 4th to 28th; Indian Territory, 10th, 11th, 15th, 18th, 20th; Rocky Mountains, from Southern New Mexico to Northern Montana, 1st to 28th; Arizona (central part), 9th, 17th, 18th; Middle Plateau, 5th, 7th to 18th, 25th, 26th; Northern Plateau, 1st, 2d, 8th to 16th, 18th, 20th, 26th, 27th; Northern Pacific coast region, 8th, 12th to 18th, 26th to 28th.

Largest monthly snow-falls.—Mount Washington, 56 inches; Beloit, Wis., 42; Little Mountain, Ohio, 38; Cisco, Cal., 33; Sterling, Ill., 32; Rockford, Ill., 31.5; Geneseo, Ill., 30; Elmira, Ill., and North Volney, N. Y., 29; Coldwater, Mich., 28; Friendship, N. Y., and Olivet, Dak., 26; Bloomfield, Wis., Marshall, Mich., and Cleveland, 25; Belvidere, Ill., and Corning, Mo., 24.5; Neillsville, Wis., Niles and Northport, Mich., 23; Minneapolis, Minn., and Pierce City, Mo., 22; Deer Park, Md., 21.

The following items regarding the remarkably severe snow-storms of the month will be found of interest: *Dakota:* Fort Bennett, 12th, snow-fall unprecedented; cattle suffering dreadfully; travel of all kinds almost impossible throughout month. Yankton, 7th, heavy blockade; business

almost suspended; great sufferings among people in interior towns for want of food and fuel; 25th, all roads again blockaded. *Illinois:* Morrison, month characterized by an unusual fall of snow and consequent heavy blockades. *Iowa:* Nora Springs, 4th to 7th, worst snow blockade experienced in this section for past 15 years. Logan, 5th, 6th, terrible snow-storm, worst in 20 years. Burlington, 12th, 18th, all roads blockaded; heaviest for many years. Keokuk, 12th, 14th, railroads blockaded; much damage to property. Dubuque, 7th to 13th, telegraph wires down in all directions; streets impassable; all travel ceased; the worst blockade for many years. *Kansas:* Creswell, 11th, snow blockade most severe for 10 years; travel of all kinds impossible. Wellington, 10th, 11th, heaviest snow-storm ever experienced. Dodge City, 11th, very severe blizzard; stopping travel of all kinds; cattle suffering severely; 14th, trains blackaded; all travel ceased; thousands of starving and freezing cattle found along the railroad; large herd of antelopes forced into town in search of food. Leavenworth, 11th, heaviest snow storm for many years; streets impassable. *Michigan:* Northport, 27th, 16 inches fell and drifted terribly; travel impossible; worst ever experienced. Marquette, 12th to 28th, heaviest storm for years; telegraph lines all down; blockade still continuing. *Minnesota:* New Ulm, 27th, heaviest snow blockade ever experienced; hundreds of families suffering for want of food and fuel; travel impossible. Saint Paul, 1st to 16th, one continuous and uninterrupted blockade; much damage and suffering; violent blizzards. *Nebraska:* North Platte, 14th, heaviest storm for years; cattle dying from cold and starvation. Omaha, 6th, most violent storm for many years; telegraph wires all down; trains blockaded; all travel ceased; much damage to buildings; 12th, all railroad travel blockaded by heavy drifts. *New York:* 3d, railroads on Long Island blockaded; storm very violent. *Ohio:* Sandusky, 1st, trains blockaded and business entirely suspended for the day. *Wisconsin:* Embarrass, 27th, worst snow blockade ever experienced; no mail; no trains; no travel of any kind. La Crosse, 7th to 17th, all communication seriously obstructed; heaviest storm for many years; great suffering and much loss to property.

Snow on ground at end of month.—North of the 37th parallel the following depths in inches were reported in the various States and Territories: Maine, 3 to 18; New Hampshire, 8 to 24; Vermont, 1 to 20; Massachusetts, 3 to 18; Connecticut and Rhode Island, trace to 2; New York, trace to 22; New Jersey, trace to 28; Pennsylvania, 5 to 16; West Virginia, trace to 3; Ohio $\frac{1}{4}$ to 25; Indiana, trace to 4; Michigan, lower peninsula, 3 to 48; upper peninsula, 12 to 36; Illinois, 1 to 18; Wisconsin, 16 to 38; Missouri, trace to 5; Iowa, $\frac{1}{4}$ to 26; Minnesota, 24 to 36; Kansas, drifts; Nebraska, trace to 12; Dakota, 3 to 33; Colorado, only 2 inches on summit of Pike's Peak, trace to 12 in lower surrounding country; Montana, 2 to 22; Wyoming, trace to 12; California, on mountain ranges.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, 65 to 78; Middle States, 66 to 84; South Atlantic States, 58 to 81; Eastern Gulf States, 51 to 75; Western Gulf States, 62 to 79; Ohio Valley and Tennessee, 64 to 74; Lower Lake region, 72 to 79. Upper Lake region, 66 to 83; Upper Mississippi Valley, 71 to 78; Missouri Valley, 66 to 87; Valley of the Red River of the North, 75 to 91; Texas, 61 to 72; Middle Plateau, 43 to 74; Southern Plateau, 30 to 47; California, 62 to 82; Oregon, 80 to 82. High stations report the following percentages not corrected for altitude: Mount Washington, 78.9; Pike's Peak, 62.3; Denver, 56.0; Cheyenne, 50.4; Eagle Rock, 78.5; Santa Fé, 56.8.

WINDS.

The prevailing winds during the month of February, 1881, at Signal Service stations are shown on the Chart by arrows which fly with the wind. Along the Atlantic coast, from Maine to North Carolina, in the interior of the Middle Atlantic States, throughout the Upper Mississippi and Missouri Valleys, and in the Middle Eastern Rocky Mountain slope they were northwesterly. In the South Atlantic and Gulf States and in the interior of Texas and New Mexico, north to east. In the Lake region, Tennessee, and the Ohio Valley, south to east. In the Pacific coast and Plateau regions, southeast to southwest.

High winds:—Winds of 50 miles and over were reported as follows: On summit of Mount Washington, 1st to 3d, 8th to 28th; on five of these dates the wind reached a velocity of 100 miles per hour; maximum wind velocity of 110 miles S.E. on the 12th. On summit of Pike's Peak, 1st, 2d, 4th, 11th, 12th, 15th, 16th, 20th, 21st, 26th to 28th; maximum wind velocity 80 miles W. on the 21st. Umatilla, 55 W., 25th. Fort Shaw, Mont., 50 S.W., 1st. Moorhead, Minn., 62 S.E., 4th. Sandusky, 64 N.E., 1st. Indianola, 51 N., 11th. New Orleans, 52 S.E., 6th. Mobile, 60 S.E., 6th. Portsmouth, N. C., 52 N.W., 1st. Kittyhawk, 52 N., 1st. Delaware Breakwater, 58 S., 12th. Cape May, 55 N.W., 16th. Wood's Holl, 52 S.E., 28th.

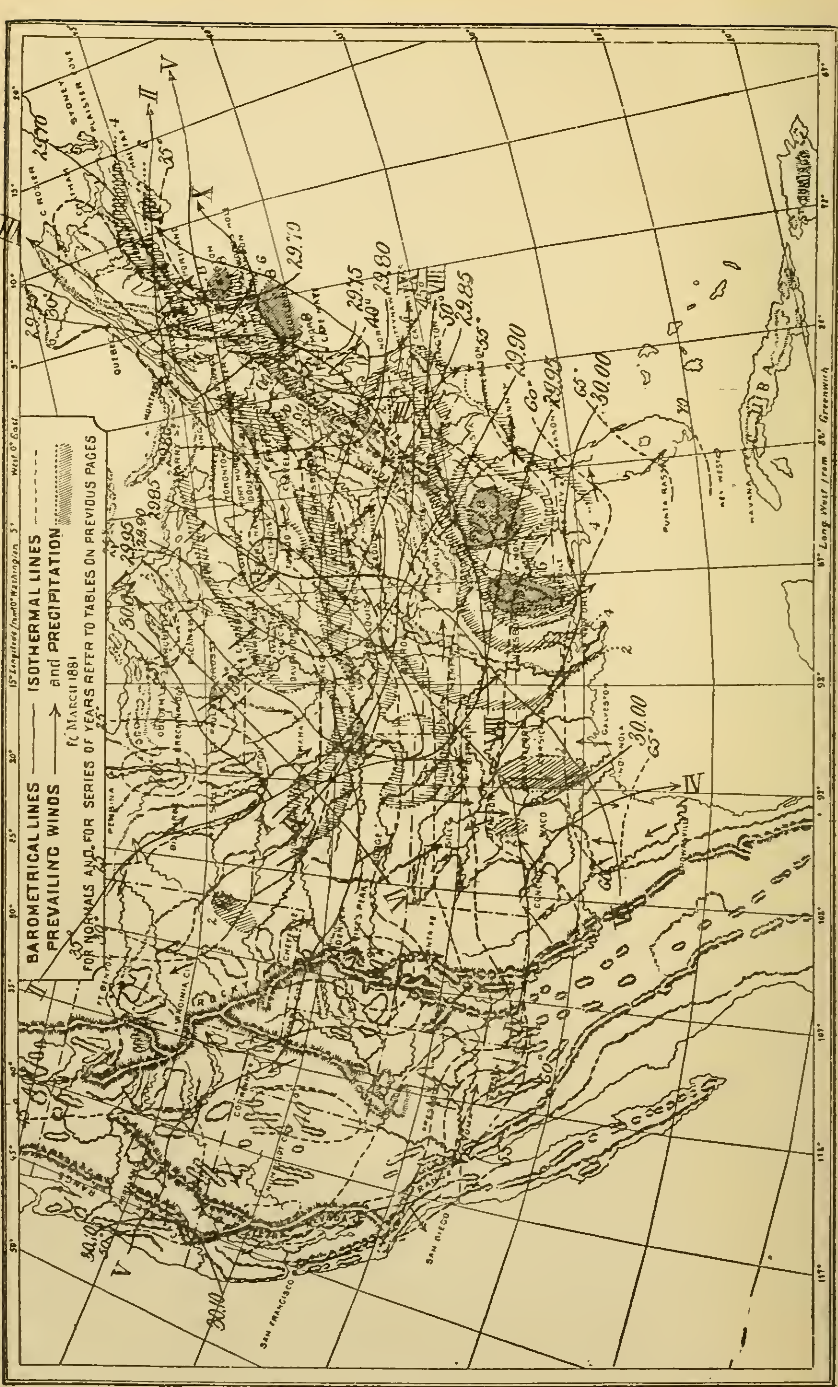
Local storms.—During the passage of low area No. VI. northeastward over Tennessee and the Ohio Valley on the 18th, opposing northerly and southerly winds, accompanied by high contrasts of temperature, prevailed in the southwest quadrant; the latter ranging from 35° to 45° between Southern Illinois and the central portion of Alabama and Mississippi. Under these peculiar atmospheric conditions there occurred, quite late in the day and within the central portion of Alabama, a terrific tornado, which passed over a part of Tuscaloosa County. Its path extended from southwest to northeast, a distance of about 15 miles, and

was characteristically narrow. The storm cloud, as usual, was accompanied by a loud roaring noise and a rotary motion from right to left. Several persons reported in connection with the passage of the cloud the presence of large balls of fire which sparkled and flashed in the belt of the wind, and seemed to be of all sizes, from the dimensions of an egg up to that of a half-bushel measure. Hail and rain followed in the track of the storm. The largest trees were twisted off near the stump or violently uprooted, and over twenty buildings were either unroofed or demolished. Heavy objects were conveyed long distances and the débris of buildings and fences were invariably carried from the east around by the north to the west, and thence by the south to the east. This storm passed but a little south and east of the track of many previous tornadoes which have travelled across this portion of the State in the same general direction.

ATMOSPHERIC ELECTRICITY.

Thunder-storms.—In the various districts they were reported on the following dates: New England, 12th, 28th; Middle Atlantic States, 5th, 12th, 19th, 25th, 26th, 27th, 28th; South Atlantic States, 11th, 16th to 19th, 21st, 22d, 23d, 27th, 28th; Eastern Gulf States, 6th, 7th, 9th, 11th, 18th, 19th, 25th, 26th, 27th, 28th; Western Gulf States, including Texas, 5th, 6th, 8th, 9th, 10th, 11th, 15th, 16th, 17th, 18th, 19th, 20th, 26th; Ohio Valley and Tennessee, 9th, 11th, 18th, 19th, 26th, 27th, 28th; Upper Lake region, 26th; Upper Mississippi Valley, 17th, 20th, 26th, 27th, 28th; Lower Missouri Valley, 5th, 6th, 19th, 20th, 26th, 27th; Arizona, 5th, 6th, 17th; California, 3d, 15th, 16th. The most important storm of the month, except along the West Gulf coast from 6th to 9th, began in the Lower Missouri Valley on the 26th, accompanying low area No. X., and as it passed eastward spread over the entire country from the Lakes to the Gulf, reaching the Atlantic coast on the 27th and 28th, where it was experienced from Havana, Cuba, northeastward to Maine. Storms of this class, gradually increasing in number and severity on the approach of spring, have been less frequent in the northern and more frequent in the southern section of the country than during the month of February, 1880. As compared with the same month of previous years since 1873, the largest number were reported during February, 1881, the next largest in February, 1878, while in 1879 the number fell to near the minimum which occurred in 1875. It is very interesting, and still further there would seem to be an accordance with supposed laws of periodicity in connection with the recurrence of these storms from season to season, to note that in a comparative study of the month of February for the past nine years, it is found, as an invariable feature, that about four-fifths of all the thunder-storms occurred between the 15th and 28th.

Auroras.—There were no remarkably brilliant displays during the month, but rather an unusual number were reported as having been witnessed over that portion of territory common to auroral manifestations, reaching from Maine westward to the 105th meridian. Displays of this nature were observed on the following dates: 1st, from stations in Nebraska northward to the northern boundary of the United States and in Northern New England; 2d, from Kansas northward to British America, and from Virginia northeastward to Maine; 20th, from Montana eastward to Lake Michigan and over New England. 26th, throughout Dakota and Minnesota, and in New Hampshire. 27th, from Southern Kansas northwestward to Montana, northward to the northern boundary of Lake Superior, and over New England. On all of these dates, and particularly the last three, extreme cloudiness prevailed over the Lower Lake region, preventing any display of auroras, even if they occurred. From various stations local displays were witnessed on the following dates: Fort Stevenson, Dak., 28th, A.M.; Spiritwood, Dak., 22d, P.M.; Saint Vincent, Minn., 16th, 20th, 22d, P.M.; Duluth, 23d, P.M.; Oswego, N. Y., 5th, A.M.; Butlington, Vt., 3d, midnight to 12.15 A.M.; 3d, 4.20 A.M. to daybreak; 6th, 2 A.M. to daybreak; 19th, 11.15 P.M. to midnight; Bangor, Me., 5th, P.M.; Eastport, 7th, 1 A.M. to 3 A.M.; Cambridge, Mass., 19th, 11 P.M.; Newburyport, Mass., 7th, 5 A.M.; 19th, P.M.; Gardiner, Me., 25th, midnight to 4 A.M.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
MARCH 1881
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES
CUBA
SAN FRANCISCO
SAN DIEGO
QUEBEC
GALVESTON
HAVANA
PUNTA RASA
KEY WEST
SYDNEY
PLAISTER COVE
CHEYENNE
WACO
80° Long West from 86° Greenwich
15° Longitude from 0° Washington
West 0° East

9. MONTHLY WEATHER REVIEW, MARCH, 1881.

BAROMETRIC PRESSURE.

The distribution of mean atmospheric pressure over the United States and Canada for the month of March, 1881, is shown by isobaric lines upon the Chart. The area of highest barometer, which has been moving steadily eastward from the Pacific since November, 1880, and which during the following months of December and January was so marked over the central portions of the country, has during the present month passed far eastward over the Atlantic, leaving a remarkably low mean pressure over the eastern sections of the country, particularly from the Ohio Valley and Virginia northeastward to Maine. The rapidity and extent of this eastward movement is shown quite forcibly on the wind chart by the general and decided northwesterly trend of the winds eastward of the Rocky Mountains. The regions of maximum pressure are to be found along the immediate Gulf and Pacific coasts, where only immaterial changes have taken place during the month. Compared with March, 1880, the pressure of the present month is strikingly at variance, as is shown by the position of the region of highest pressure, which in 1880 occupied the precise region now embraced by the abnormally low pressures of the present month.

Barometric ranges.—The range of pressure during the month has varied in the extremes from 0.35 inch at Key West to 1.42 inches at Boston. Ranges of 1.00 and above were reported from stations in Oregon, Washington Territory, Idaho, and Southwestern Montana, throughout the Upper Mississippi and Lower Missouri Valleys, the southern portion of the Upper Lake region and thence northeastward to Newfoundland. In Tennessee and from North Carolina south and westward the range nowhere rises above 0.98, except at Fort Gibson, where it reaches 1.03, while in general it varies from 0.5 to 0.75, with the lowest ranges along the immediate Gulf coast. The range everywhere increases with the latitude, being on the Pacific coast from 0.51 at San Diego to 1.12 at Olympia, and on the Atlantic coast as given above. Along the Gulf coast the range increases gradually from 0.35 at Key West to 0.74 at Brownsville, Tex.

Areas of high barometer.—Six such areas are described for the month of March, 1881, though only one (No. 1) exercised any special influence on the climatic conditions of the country; but the month is remarkable for deficiency in pressure, especially in the Eastern States. On the New

England and Middle Atlantic coasts this deficiency ranges from 2.5 to 3 inches, probably the most notable deficiency that has occurred since the establishment of the Signal Service. It is also worthy of note that the minimum temperatures are not, as is the general rule, associated with the areas of high barometer, but in the majority of instances have, in March, occurred after the passage of the centre of low area and after the veering of winds to the northwest, but before the pressure had reached its maximum or risen above the normal.

No. I.—On the 1st there was a great rise in pressure in Washington Territory and Oregon, following an area of low barometer, which on the previous day advanced to the eastward over British Columbia. At the morning observation of the 2d the following were the highest reported barometers: Olympia, 30.44 or 0.43 above the normal; Portland, 30.48 or 0.41 above the normal; the rise in pressure for one day at these points being respectively 0.54 and 0.46 inches. The winds on the coast continued southerly during this rise, which is frequently the case on the Pacific slope; the rise in pressure appearing to come from the southwest, and there is seldom the veering of winds to the northwest, after the passage of the centre of low area, which is so frequent a feature of storms east of the Rocky Mountains. On the 2d the centre of the area of highest pressure moved slowly to the eastward into Idaho and Utah, but the greatest rise, averaging one-half of an inch, occurred in Colorado. On the 3d the pressure, slightly yielding, continued above the mean from the Pacific coast to the Mississippi Valley, while on the Texas coast there was a considerable rise. Cautionary off-shore signals, changed from cautionary, that had been ordered in advance of low area No. II., were justified by the following maximum velocities: Indianola, 43 N.; Galveston, 32 N. On the 4th the region of highest barometer was transferred to Manitoba. On the 5th there was a general rise in pressure east of the Mississippi River, but the centre of the high area remained in the Lower Missouri Valley. On the 6th there was a rise averaging nearly half an inch in the Lower Lake region, and the isobars of high pressure included the Lakes, the Ohio Valley, and Tennessee. On the 7th the highest area extended from the Lower Lakes to the South Atlantic coast. On the 8th it disappeared in advance of low area No. IV., then moving to the eastward over the Ohio Valley. In connection with this high area the minimum temperatures of the month were reported from the Lower Missouri Valley, Arkansas, Indian Territory, and Northeastern Texas on the 5th, and from the Ohio Valley to South Atlantic coast on the 5th and 6th.

Areas of low barometer.—Nine such areas have had their tracks charted for the month of March, 1881. (No. I. not charted.) Of these, one (No. V.) has its track charted across the continent, finally disappearing beyond the New England coast. Another depression (No. VII.) undoubtedly crossed the continent from the Pacific over Mexico, but not

within the limits of the chart. Four (Nos. II., IV., VII., and X.) exhibited great energy at some portions of their tracks. Five (Nos. III., VI., VII., IX., and X.) developed within the limits of the United States. One (No. VII.), after crossing the continent and leaving the Saint Lawrence Valley on the 21st, became a permanent low area for the rest of the month in the maritime provinces and Nova Scotia; the lowest reported barometer was at Chatham, 28.82, at the afternoon observation of the 27th, which was 1.05 inches below the normal. Two depressions (Nos. VIII. and IX.) skirted the edge of the great depression (No. VII.), but neither developed much energy nor merged with the original low area.

TEMPERATURE OF THE AIR.

The mean temperature of the air for March, 1881, is shown by the isothermal lines on the Chart. Throughout a majority of the various districts of the country the temperature is below the normal, while in the Upper and Lower Lake regions no change occurs. The departures of excess, ranging from +0.4 in the Southern Plateau to +8.5 in the Northern Rocky Mountain slope, are confined, with a single exception, to the northern sections of the country, or above parallel 40°; those of deficiency, ranging from −0.4 in the Middle Atlantic States to −4.8 in the South Atlantic States, embracing the Southern districts, are most marked in the Gulf and South Atlantic States.

PRECIPITATION.

The general distribution of rain-fall (including melted snow) for March, 1881, is shown on the Chart from the reports of over 500 stations. The regions of heaviest precipitation are to be found along the immediate coast of Washington Territory, throughout Alabama and Georgia, in Western North Carolina, and from Northern New Jersey eastward along the coast of Connecticut and Rhode Island, and thence northward on the Massachusetts coast to Maine. The regions of least precipitation occupy Western Montana, Southwestern Wyoming, Northwestern Utah, Northern Nevada, Central New Mexico, and Southwestern Arizona. As compared with the mean of past years, the rain-fall for the present month is in general below the average, only five districts out of a total of seventeen reporting an excess. Departures of excess range from +0.15 in the Eastern Gulf States to +1.67 in New England; those of deficiency, from −0.1 in the Upper Mississippi Valley to −4.94 in the Northern Pacific coast region. The rain-fall of the Rocky Mountain and Plateau districts is quite uniform in the various sections, but the range for the whole territory (from 0.00 to 4.95 inches), though considerable, is not unusual.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 11 to 25; Middle Atlantic States, 11 to 19; South Atlantic States, 9 to 15; Eastern Gulf States, 3 to 13; Western Gulf States, 9 to 11; Ohio Valley and Tennessee, 15 to 22; Lower Lake region, 16 to 23; Upper Lake region, 9 to 18; Upper Mississippi Valley, 8 to 15; Missouri Valley, 9 to 11; Red River of the North Valley, 6 to 11; Texas, 0 to 8; Rocky Mountains, 5 to 12; Middle Plateau, 3 to 10; Southern Plateau, 1 to 11; California, 1 to 8; Oregon, 5 to 21; Washington Territory, 11 to 20.

Cloudy days.—The number varied in New England from 10 to 24; Middle Atlantic States, 8 to 20; South Atlantic States, 5 to 12; Eastern Gulf States, 4 to 11; Western Gulf States, 6 to 9; Ohio Valley and Tennessee, 6 to 21; Lower Lake region, 13 to 21; Upper Lake region, 10 to 16; Upper Mississippi Valley, 10 to 18; Missouri Valley, 8 to 11; Red River of the North Valley, 5 to 9; Texas, 1 to 13; Rocky Mountains, 4 to 10; Middle Plateau, 3 to 8; Southern Plateau, 0 to 5; California, 0 to 6; Oregon, 9 to 14; Washington Territory, 5 to 19.

Rain or snow from a cloudless sky.—Bismarck, 18th.

Snow.—In several instances snow has fallen at points having a more southern latitude than occurred during the past month of February. In California, Arizona, and New Mexico it fell along the extreme southern boundaries; in Western Texas it was reported from near latitude 30° on the 20th, and in the northern part of the State as low as latitude 35° on the 18th, 19th, and 20th; in Arkansas below latitude 35° on the 21st; in Georgia near latitude 35° on the 21st, 22d, 29th, 30th, and on the North Carolina coast near latitude 35° on the 5th. In the various districts north of parallel 35° it fell on the following dates: *New England,* 1st to 6th, 11 to 21st, 23d, 24th, 27th to 31st; *Middle Atlantic States,* 1st, 3d, 4th, 6th, 12th, 13th, 14th, 23d to 27th, 30th, 31st; *Tennessee,* 3d to 6th, 20th to 24th, 29th to 31st; *Ohio Valley,* 1st to 7th, 11th, 12th, 13th, 19th, 25th, 29th to 31st; *Lower Lake region,* 1st to 7th, 12th to 15th, 20th to 31st; *Upper Lake region,* 1st to 8th, 12th to 21st, 24th, 27th to 31st; *Upper Mississippi Valley,* 1st to 8th, 11th to 25th, 27th to 31st; *Minnesota,* 1st to 8th, 12th to 17th, 24th, 28th to 31st; *Missouri Valley,* 1st to 16th, 18th to 22d, 25th to 31st; *Indian Territory,* 3d, 4th, 18th, 19th, 20th, 21st; *Rocky Mountains,* 1st to 26th, 28th; *Southern Plateau,* 5th, 6th, 9th, 10th, 13th to 20th; *Middle Plateau,* 1st, 5th, 11th to 18th; *Northern Plateau,* 1st, 2d, 4th, 5th, 7th, 9th to 18th; California, Campo, 13th, 16th, 17th; Visalia, 14th; Red Bluff, 9th, 10th; Fort Bidwell, 4th, 8th, 9th to 12th, 14th, 15th; Northern Pacific coast region, 4th, 9th, 11th to 14th, 16th, 18th.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, 68 to 77; Middle Atlantic States, 54 to 77;

South Atlantic States, 54 to 80; Eastern Gulf States, 55 to 70; Western Gulf States, 57 to 71; Ohio Valley and Tennessee, 57 to 72; Lower Lake region, 76 to 81; Upper Lake region, 73 to 82; Upper Mississippi Valley, 63 to 75; Missouri Valley, 65 to 75; Red River of the North Valley, 74 to 85; Texas, 33 to 73; Middle Plateau, 29 to 65; Southern Plateau, 27 to 49; California, 60 to 73; Oregon, 64 to 76; Washington Territory, 70 to 82. *High stations* report the following percentages not corrected for altitude: Pike's Peak, 65.7; Santa Fé, 48.7; Cheyenne, 52.9; Denver, 56.2; Mount Washington, 86.3.

WINDS.

The prevailing winds during the month of March, 1881, at Signal Service stations, are shown on the chart by arrows which fly with the wind. Throughout the country, east of the 97th meridian, the winds, with hardly an exception, were from west to northwest. Throughout the Rio Grand Valley southeasterly. Along the Eastern Rocky Mountain slope north to northwest. In Central Texas and the Plateau regions, variable. In the Middle and Southern Pacific coast regions, northerly, and in the Northern Pacific coast region, southerly.

High winds.—Winds of 50 miles and over were reported as follows: On summit of Mount Washington, 1st to 4th, 9th, 10th, 19th, 20th, 23d to 31st; on seven of these dates the wind reached a velocity of 100 miles or over; maximum wind velocity, 132 miles N.W. on the 27th. On summit of Pike's Peak, 1st, 2d, 4th, 15th, 20th to 22d; maximum wind velocity, 64 miles N.W. on the 1st. Thatcher's Island, 66 N.W., 11th; 65 N.E., 30th. Sandusky, 54 N.W., 30th. Barnegat, 52 E., 30th. Cape May, 52 N.W., 1st; 51 N.W., 2d; 50 N.W., 26th, 27th. Kittyhawk, 52 N.E., 26th; 55 W., 31st. New Shoreham, 52 N.E., 30th. Cape Hatteras, 58 S.W., 30th. Dodge City, 55 N.W., 2d; 56 N.W., 11th, Delaware Breakwater, 50 S.W., 4th; 70 N.E., 9th. Portsmouth, N. C., 72 S.W., 30th.

Local storms.—Near Fayette, Jefferson County, Mississippi, 18th, 2.30 P.M., violent tornado passed from S.W. to N.E., a distance of about five miles; width of storm track about 100 yards, over which every movable article was swept away. The Natchez and Jackson Railroad bridges across Colle's and Ball's Creeks were nearly demolished, cutting off communication for several days. This tornado developed in connection with the passage of low area No. VII. northeastward from the Rio Grande Valley across the northwestern portions of the States of Louisiana and Mississippi. On the afternoon of the 18th cold northwesterly winds prevailed to the northward of the low area, in Arkansas, Indian Territory, and Missouri, while to the southward along the Western Gulf coast, opposing warm southerly winds obtained, presenting a contrast in temperature of from 20° to 30°. Galena, Cherokee County, Kansas, 16th, A.M., most violent storm that has ever visited

this section. In its appearance it was described as very similar to the terrible tornado that devastated Marshfield, Mo., in April, 1880. Direction of storm path S.W. to N.E., width of track about 300 yards. Every movable object in the storm's path was carried away with irresistible force, but fortunately its course was turned aside from the more densely populated portion of the city, which prevented very serious disasters. This tornado developed in the southwest quadrant of an area of low barometer, described as No. VI. on Chart. On the afternoon of the 16th, this low pressure extended from the lower Missouri Valley northeastward to the Upper Lake region. In rear of this area cold northwesterly winds with snow prevailed, opposed in the West Gulf States by warm southerly winds, which presented a contrast in temperature of from 20° to 30°. Sumterville, Sumter County, Alabama, 23d, 5 P.M., very violent tornado passed a little north of station. Direction of storm path S.W. to N.E.; width of track about 40 yards. Several large buildings and many outhouses, stables, etc., were demolished. Heavy objects were transported considerable distances, and in some instances chickens were carried over a quarter of a mile. The appearance of the storm cloud was described as fearful, resembling huge volumes of black smoke ascending and whirling in the form of a funnel, accompanied in its passage by a heavy rumbling noise. This tornado developed in connection with the passage of low area No. VIII. over the northern portion of the South Atlantic and Eastern Gulf States. After the immediate passage of this low area to the eastward, cold northwesterly winds prevailed to the northward of Alabama, while in the southern portion of the East Gulf States warm southerly winds obtained, showing a contrast in temperature of from 15° to 20°

ATMOSPHERIC ELECTRICITY.

Thunder-storms.—In the various districts they were reported on the following dates: New England, 1st, 2d, 16th, 20th; Middle Atlantic States, 3d, 4th, 9th, 12th, 13th, 16th, 19th, 20th, 29th, 30th, 31st; South Atlantic States, 3d, 18th, 19th, 22d, 25th, 26th, 29th, 30th; Eastern Gulf States, 3d, 7th, 9th, 11th, 12th, 13th, 16th to 19th, 21st, 25th, 26th, 29th; Western Gulf States (excluding Texas), 7th, 10th to 12th, 14th to 19th, 21st to 25th, 28th to 29th; Texas, 6th to 11th, 15th. 18th, 24th, 25th, 28th, 29th; Ohio Valley and Tennessee, 2d, 3d, 11th, 12th, 16th, 18th, 19th, 25th, 28th, 29th; Upper Mississippi Valley, 2d, 11th, 14th to 16th, 25th; Lower Missouri Valley, 1st, 2d, 9th, 10th, 14th to 16th, 25th; Arkansas and Indian Territory, 6th, 9th, 10th, 11th. 14th, 15th, 18th, 24th; New Mexico and Arizona, 8th, 9th; Nevada, Carson City, 31st; California, Red Bluff, 9th, 20th; Yosemite Valley, 31st; Oregon and Washington Territory, along the Valley of the Willamette, 1st, 23d, 26th. No thunder-storms were reported from the Lake regions, the Northwest or the Rocky Mountain regions.

Auroras.—In general there were no unusually brilliant displays reported, but the element of frequency affected quite prominently their appearance in the Northwest. The most important manifestation of auroral display was shown on the evening of the 18th by a somewhat remarkable continuity of observation extending throughout the Lake region, and reaching in an unbroken line from Halifax, N. S., westward to the northwestern extremity of Montana.

Telegraphic communication interfered with by atmospheric electricity.—Fort Grant, Ariz., 8th, peculiar electrical condition of the atmosphere; sufficient motive force to occasionally work instruments on the line between this station and Fort Verde, although there was no battery attached. The galvanometer was constantly affected with an electromotive force of ordinary intensity which acted in a contrary direction to that usually displayed. Later in the day quantity of force increased, but intensity diminished between the two stations; finally current changed to opposite direction, followed soon after by a fluctuating quantity. La Mesilla, 5th; Jacksborough, Texas, 6th, 9th, 11th; San Antonio, Texas, 24th, Laredo, Texas, 25th, discharges so heavy as to melt brass connections in office.


BAROMETRICAL LINES —— ISOTHERMAL LINES - - - - - -
PREVAILING WINDS ——→ and PRECIPITATION
for April 1881
VII
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES
81° Long West from 88° Greenwich
CUBA
ROCKY
NEVADA
SAN FRANCISCO
SAN DIEGO
GALVESTON
KEY WEST
HAVANA
PUNTA RASSA

10. MONTHLY WEATHER REVIEW, APRIL, 1881.

BAROMETRIC PRESSURE.

The distribution of mean atmospheric pressure over the United States and Canada for the month of April, 1881, is shown by isobaric lines upon the Chart. The region of lowest pressure remains about stationary over New England and the maritime provinces, but with barometric readings somewhat lower over the latter section than for any previous April since 1874. The regions of highest pressure occupy the Eastern Gulf coast and the Northern Pacific coast region. Compared with April, 1880, the distribution of pressure is about the same, except that the area of high is less marked and the area of low more confined. The latter, extending westward to the Missouri Valley in April, 1880, is entirely superseded in the present month by an increase in the extreme of +0.2 inch, and over the Lake region of +0.12 inch.

Barometric ranges.—The range of pressure during the month has varied in the extremes from 0.25 inch at San Diego to 1.37 inches at Eastport, and 1.38 inches at Fort Buford. Ranges of 1.00 and above were reported from the following stations: New York City and Albany, 1.00; Fort Sill, 1.01; Henrietta, Tex., and Burlington, Vt., 1.02; North Platte, 1.03; Springfield, Mass., and Moorhead, Minn., 1.05; New London, 1.06; Fort Gibson, 1.07; Kittyhawk and Yankton, 1.08; Thatcher's Island, 1.1; Fort Elliott, 1.12; New Shoreham, 1.13; Hatteras, 1.15; Saint Vincent, 1.16; New Haven and Boston, 1.17; Dodge City, 1.18; Portland Me., 1.2; Newport, 1.21; Mount Washington, 1.22; Wood's Holl, 1.32. In general, the range has been greatest from Texas northeastward to New England, the latter district being the only one where the range at every station was above 1.00 inch. Throughout the country, except from Texas directly northward, the range increases with the latitude. As compared with past months, there has been a marked increase of range over the Florida peninsula, varying from 0.11 to 0.17 inch. Along the southern boundary of the country, the range increases from the southwestern and southeastern extremes (California and Florida) inward to the maximum in Texas, while over the northern boundary two maxima were reached, one in New England and the other in the extreme Northwest.

Areas of high barometer.—Five such areas for the month of April have been sufficiently marked to merit a brief description, though none have exercised any special influence over the climatic conditions of the country

The minimum temperatures of the month in the interior of the country, occurring on the 1st and the 2d, are associated with high area No. 1. The minimum temperatures in the Middle States and New England, occurring on the 5th, 6th, and 7th, are associated with a great depression then central over the Gulf of Saint Lawrence, and extending into the districts named. A deficiency of both pressure and temperature was reported from New England and the Middle States.

No. II.—During the movement of high area No. I. to the south, on the 1st and 2d, the pressure, although diminishing, remained above the normal in Dakota and Manitoba, but on the 2d a marked rise took place in the Saskatchewan Valley, and on the 3d the high area extended from Montana and Dakota to Texas, the highest readings being reported from the Missouri Valley. On the 4th, the highest barometers were reported from the Southwest, but on the ensuing day this area ceased to continue as a high pressure. In connection with this high area, a maximum velocity of 51 miles from the northeast was reported from Indianola.

No. III.—On the 7th and 8th, after the passage of low area No. I., to the eastward, there was a great and general rise in pressure west of the Mississippi River.

Areas of low barometer.—Seven such areas are charted for the month of April, 1881. None are traced from the Pacific coast. Nos. II., III., and IV. are specially interesting, because No. III. was a secondary development of No. II., and No. IV. a secondary development of No. III. Of the storms of the month, the only one showing great energy was No. IV. Low area No. X., of the March Review, was traced to Nova Scotia on the last day of that month. The pressure remained below the normal in that region and nearly stationary in position until the 10th, the lowest reported reading being at Chatham at the morning observation of the 4th, 29.05, or 0.8 inch below the normal. In the mean time, low area No. I., in its march to the eastward, skirted the border of this depression, but did not unite with it within the limits of our Charts.

Nos. II., III., and IV.—These three depressions should be described together, as No. III. was a secondary development of No. II., and No. IV. a secondary development of No. III. No. II.—On the 10th, there was a considerable decrease in pressure in Northwestern Texas and Indian Territory, showing the development of a low area in that region, which, at the midnight report, was located as indicated on the Chart. On the 11th, it pursued a northeasterly track over Arkansas and Missouri. The precipitation thus far was confined to the northeast quadrant of the depression. On the 12th, at the morning report, the centre of low area had moved near Louisville, when the pressure, 29.62, was 0.34 inch below the normal. At the morning report, the pressure in Nova Scotia was below the normal, the isobar of 29.8 inclosing Chatham, Halifax, and Sidney; in the United States, the isobar of 29.8 included the Ohio Valley and Lake Erie. The low areas above referred to were

divided by a belt extending from Northwestern New York to Rhode Island, where the pressure was 30.00; the barometric gradient was slight, and the meteorological conditions were not favorable to the development of storm energy. During the day, area No. II. was filled up by inflowing air. In the mean time, during the passage of No. II. to the eastward, the barometer had remained below the normal and falling in Texas, and at the A.M. report of the 12th the circulation of the winds indicated the formation of a new and independent centre of depression in Northern Texas and Indian Territory, which during the day extended northeastward into Tennessee and the Ohio Valley. On this day, the following great falls in temperature for the preceding twenty-four hours were reported: Fort Elliott, 28°; Fort Sill, 46°; Fort Gibson, 37°; Concho, 31°; Stockton 26°; Denison, 29°; Little Rock, 22°; Memphis, 26°; Cairo, 25°; St. Louis, 21°. On the 13th, with diminishing energy, the storm centre passed off the Middle Atlantic coast. On this day, the cold wave, before noticed, moved to the southeastward, the temperature falling 20° at Louisville and Knoxville, 21° at Nashville, 23° at Chattanooga, 25° at Memphis, 26° at Vicksburg, 27° at Shreveport, and 23° at Montgomery.

TEMPERATURE OF THE AIR.

The mean temperature of the air for April, 1881, is shown by the isothermal lines on the Chart. West of the 100th meridian the temperature is everywhere above the normal, while in every district to the eastward it is below, except in the West Gulf States, where it is normal.

PRECIPITATION.

The general distribution of rain-fall (including melted snow) for April, 1881, is shown on the Chart, from the reports of over five hundred stations. In general the rain-fall is considerably below the normal; only two remote and comparatively unimportant districts, viz., the Florida peninsula and the Northern Pacific coast region, show the slightest excess. The most marked feature of this important subject for the month is not so much the deficiency in any particular district as that this deficiency is remarkably general, affecting in a striking manner those districts which are usually subject to heavy precipitation at this period of the year. As compared with the previous records of Signal Service observations for the month of April since 1874, no such widespread deficiency has ever been reported. The departures from normal are most marked, save two exceptions, over the northern sections of the country, the largest, 2.34, being reported from New England. There has been little, if any, variation from the accustomed diversity of rain-fall over the Rocky Mountain and Plateau districts; the largest amount, 4.64 inches, fell on the

summit of Pike's Peak, while an entire absence of rain was reported from scattering stations in Arizona, California, Nevada, and Utah.

Rainy days.—The number of days on which rain or snow has fallen varies as follows: New England, 7 to 19; Middle Atlantic States, 7 to 17; South Atlantic States, 5 to 15; Eastern Gulf States, 5 to 9; Western Gulf States, 2 to 12; Ohio Valley and Tennessee, 10 to 19; Lower Lake region, 7 to 14; Upper Lake region, 4 to 15; Upper Mississippi Valley, 10 to 20; Missouri Valley, 3 to 12; Red River of the North Valley, 8 to 13; Texas, 4 to 1; Rocky Mountains, 5 to 15; Middle Plateau, 4 to 10; Southern Plateau, 1 to 9; California, 3 to 30; Oregon, 5 to 18; Washington Territory, 14 to 19.

Cloudy days.—The number varied in New England from 2 to 10; Middle Atlantic States, 5 to 12; South Atlantic States, 2 to 13; Eastern Gulf States, 1 to 9; Western Gulf States, 5 to 9; Ohio Valley and Tennessee, 7 to 16; Lower Lake region, 6 to 10; Upper Lake region, 2 to 9; Upper Mississippi Valley, 4 to 12; Missouri Valley, 6 to 14; Red River of the North Valley, 3 to 16; Texas, 1 to 10; Rocky Mountains, 5 to 10; Middle Plateau, 3 to 11; Southern Plateau, 1 to 6; California, 1 to 13; Oregon, 11 to 19; Washington Territory, 13 to 15.

Snow.—The extreme southern latitude at which snow has fallen is a remarkable feature of the month. Between the 77th and 107th meridians no less than seven localities report snow as far south as latitude 35° between the 1st and 13th, and, in two instances, below that parallel. In the various northern districts it fell on the following dates: New England, 1st, 2d, 5th to 7th, 11th to 19th, 22d, 24th, 25th, 26th, 29th, 30th. Middle Atlantic States.—1st to 8th, 11th to 13th. North Carolina.—Charlotte, 1st, 4th. Tennessee.—1st, 4th, 5th. Ohio Valley.—1st to 6th, 9th, 11th, 13th, 15th. Lower Lake region.—1st to 8th, 11th to 15th.—Upper Lake region.—1st to 6th, 10th to 16th, 28th, 29th. Upper Mississippi Valley.—1st to 4th, 7th to 15th, 24th to 26th. Missouri Valley.—2d to 12th. Valley of the Red River of the North.—1st to 3d, 8th, 13th to 15th. Northern Rocky Mountain Slope.—1st to 12th, 23d to 25th. Rocky Mountains.—5th to 14th, 20th to 23d. Northern Plateau.—5th to 11th, 12th, 16th, 17th. Utah.—9th to 12th. Oregon.—Albany, 8th, 18th. California.—In mountains, 17th, 22d, 23d.

Snow from a cloudless sky.—Logansport, Ind., 2d, from 8.30 to 9 P.M., fine particles of snow fell, there being no clouds visible for two hours previous, the moon and stars shining with but slightly diminished brilliancy.

Snow on ground at end of month.—Isolated stations report the following depths in inches: Auburn, N. H., 5; Mount Washington, 20; Burlington, Vt., 0 to 1; Oswego, N. Y., trace; Fallsington, Pa., 0.25; Edgerton, Wis., 2.81; near Fort Madison, Iowa, 4.50; Morriston, Dak., 18; Deadwood, Dak., trace; Pike's Peak, 16.75.

Hail-storms were of considerable frequency west of the Mississippi and north of the Ohio.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, 54 to 80; Middle Atlantic States, 54 to 78; South Atlantic States, 55 to 85; Eastern Gulf States, 59 to 77; Western Gulf States, 54 to 75; Ohio Valley and Tennessee, 60 to 68; Lower Lake region, 62 to 74; Upper Lake region, 58 to 73; Upper Mississippi Valley, 61 to 72; Missouri Valley, 62 to 73; Red River of the North Valley, 72 to 76; Texas, 50 to 75; Middle Plateau, 33 to 42; Southern Plateau, 30 to 76; California, 43 to 77; Oregon, 56 to 69; Washington Territory, Olympia, 78. High stations report the following percentages not corrected for altitude: Pike's Peak, 70.8; Santa Fé, 32.7; Cheyenne, 51.2; Denver, 45.2; Mount Washington, 79.6.

WINDS.

The prevailing winds during the month of April, 1881, at Signal Service stations are shown on the Chart by arrows, which fly with the wind. Throughout the country east of the Mississippi the winds were from west to northwest except southwest along the South Atlantic coast. In the Western Gulf States and Texas, southeast to southwest and south. Along the eastern slope of the Rocky Mountains, northeast to northwest and north. Over the Middle and Northern Plateau regions, west and southwest. Southern Plateau, variable. Along the Pacific coast, west and northwest, except southerly in the North Pacific coast region.

High winds.—Winds of 50 miles per hour and over were reported as follows: On the summit of Mount Washington, 2d to 7th, 11th, 12th, 14th to 19th, 21st to 23d, 24th, 25th, 26th, 28th, 29th, 30th; on four of these dates the wind reached a velocity of 100 miles or over; the maximum velocity, 120 miles N.W., occurred on 2d, 3d, 29th. On the summit of Pike's Peak, 2d, 13th, 14th, 15th; maximum velocity 68 N.W., 14th; Eastport, 52 N.E., 15th; Thatcher's Island, 55 N.E., 15th; New Shoreham, 60 N.E., 15th; Cape Henry, 52 N., 14th; Kittyhawk, 76 N.E., 14th; Hatteras, 60 N., 14th; Portsmouth, N. C., 88 N.E., 14th; Fort Macon, N. C., 52 N., 14th; Indianola, 51 N.E., 4th; North Platte, 54 S., 30th; Fort Stephenson, Dak., 50 W., 26th; Saint Vincent, Minn., 56 S.W., 26th.

Local storms.—De Soto County, Mississippi, 12th, about 2 P.M., violent tornado appeared to originate near Commerce, a small town on the Mississippi, where it wrecked ten cabins, three gin-houses, and demolished a store and its contents, valued at $2,000. From this place the storm passed in an E.N.E. direction, and was next heard of at a point

about five miles northwest of Hernando. In this vicinity the loss to property and life was very severe; 25 buildings of various kinds were totally demolished, and 10 persons killed. Length of storm-path about 25 miles, width from 100 to 300 yards. Very heavy rain and hail followed this tornado at Senatobia and several other points in the vicinity, in some cases hail-stones falling the size of hen's eggs. It is of importance to note that the occurrence of electricity or thunder was not reported as observed from any part of the tornado's path. Through portions of Prairie, Monroe, Lee, and Saint Francis Counties, Arkansas, 12th, about 2 P.M., violent tornado passed from southwest to northeast, visiting several towns, among which were Brinkley, Forrest City, and Cotton Plant. After the passage of the storm at these points, showers of jagged pieces of ice, 4 to 6 inches in width and 2 to 2½ inches in thickness, fell, resembling broken river ice. These tornadoes developed in connection with the passage of low area No. III. northeastward from Texas to the Ohio Valley. On the afternoon of the 12th warm southerly winds prevailed along the West Gulf coast and in the interior of the bordering States, which were opposed to the northward of Arkansas and Mississippi by cold northerly winds, presenting a contrast in temperature of from 35° to 50°. Still farther northward, in the States of Illinois, Iowa, and Colorado, snow was reported, with temperature of 19°, 26°, and 27°, and to the southward, in lower Texas, temperatures of 80° to 90° occurred. Safford, Chase County, Kansas, 30th, about 6 P.M., tornado passed from southwest to northeast over section of country three miles north of station; path very narrow and destruction of property considerable. This storm developed in connection with an area of low barometer then extending from Northern Kansas to Central Minnesota and Dakota. On the afternoon of the 30th warm southerly winds, with temperatures ranging from 60° to 87°, prevailed over the lower Missouri Valley, opposed to the northward in Dakota and Minnesota by northerly winds, producing contrasts of temperature ranging from 20° to 30°. At Emporia, Kans., very high southerly winds were reported during the day. Total movement from 8.35 to 10.35 P.M., 111 miles; from 10.03 to 10.08 P.M., velocity reached the rate of 72 miles per hour; at 10 P.M., velocity 64 miles per hour. Clay Centre, Kans., 24th, very violent, blowing down houses and trees, and overturning railroad cars. Mammoth Cave, Ky., 12th, very severe, maximum wind velocity 60 miles. Garysburg, N. C., 29th, blowing down trees and buildings. Elsworth, N. C., 8th, buildings unroofed and other property damaged. Clarksville, Tenn., 28th, 7 A.M., very violent wind-storm; several buildings unroofed. Fort Douglas, Utah, 18th, very violent, blowing down fences and unroofing buildings.

Water-spouts.—Cairo, 28th, three water-spouts observed one-half mile southwest of station and in close proximity. Toronto, Canada, 26th, 10 A.M., on lake.

ATMOSPHERIC ELECTRICITY.

Auroras.—There have been an unusual number of displays reported from the Lake region. Most of them occurred on dates coincident with those in other districts to the east and west, thus completing the connection which frequently has been wanting over this region, from one cause or another, generally presumed to be cloudiness and therefore frustrating any attempt to trace a continuous line of observation from east to west, which from the nature of auroral display is known to be its ordinary disposition.


BAROMETRICAL LINES
ISOTHERMAL LINES
PREVAILING WINDS
and PRECIPITATION
for MAY 1881
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES

11. MONTHLY WEATHER REVIEW, MAY, 1881.

BAROMETRIC PRESSURE.

The distribution of mean atmospheric pressure over the United States and Canada for the month of May, 1881, is shown by isobaric lines upon the Chart. The area of low pressure, which remained about central over New England and the Canadian maritime provinces during the past three months, which has now disappeared, being replaced by pressures ranging from 30.05 to 30.11, which are the highest on record for any June since 1874, and, together with the Northern Pacific coast, are the regions of highest pressure for the month. The regions of lowest pressure occupy the Upper Mississippi and the Lower Missouri Valleys and California. Compared with the preceding month, the pressure is considerably higher east of the 87th meridian, ranging from +0.05 to +0.46, while to the westward of that boundary a decrease is observed, ranging from −0.02 to −0.14. Compared with the same month in previous years, the disposition of pressure is very much the same, except the remarkably high area over the Canadian maritime provinces. Heretofore the pressure has averaged about 29.95 in this section, while the high areas were common to the Northern Pacific coast and the Eastern Gulf States. It is interesting to note in this connection that in the preceding month (April) the lowest pressures for many years prevailed over the Canadian maritime provinces, while in the present month the reverse prevails to even a greater degree.

Departures from the normal values for the month.—The pressure is everywhere above the normal, except in the Gulf States (excluding Texas), Florida, and along the Pacific coast. From the interior of the country the departures increase to the east and west, the areas of greatest deviations coinciding with the regions of highest and lowest pressure, viz., New England and the Missouri Valleys.

Areas of high barometer.—Six such areas during the month of May have been sufficiently marked to merit description. The minimum temperatures for the month occurring in the Northwest on the 2d; in the Lake region on the 2d, 3d, and 4th; in the Ohio Valley on the 3d and 4th; in New England and the Middle Atlantic States on the 4th and 5th, are associated with high area No. 1. The minimum temperatures in Tennessee, the East Gulf, and southern portion of the South Atlantic States occurring on the 18th and 19th, are associated with a depression then central off the South Atlantic coast.

No. I.—This area, which was described as high area No. V. in the April Review, was central in the Middle Atlantic States at midnight of April 30th. It moved southward during the 1st of May, and at midnight was off the South Atlantic coast. During the 2d the pressure gradually diminished in the South Atlantic States.

No. II.—At the morning report of May 1st, the pressure was above the normal at all stations east of the Rocky Mountains, except Marquette and Escanaba, and an area of high barometer was approaching the Lake region from the Northwest, where the pressure was 0.2 inch above the normal. This area moved slowly eastward, and on the morning of the 2d was central in Manitoba as an area of 30.4 inches. During the 2d the temperature fell decidedly in the Lake region. Continuing its eastward movement the area was central on the morning of the 3d in Ontario, when the isobaric line of 30.4 inches embraced the whole of the Lake region, where the temperatures were from 12° to 19° below the normal. The lowest temperatures reported were 26° at Alpena and 32° at Duluth. On the morning of the 4th the area of 30.4 inches embraced New England, the Middle Atlantic States, and the greater portions of the Lake region and the Canadian maritime provinces. The temperatures continued below the mean in all districts east of the Rocky Mountains, excepting the Gulf States. During the 5th and 6th the pressure on the North Atlantic coast gradually decreased, the area moving eastward and disappearing on the latter date. Cautionary signals were ordered up on the morning of the 3d from Delaware Breakwater to Cape Hatteras. They were lowered at Chincoteague and Delaware Breakwater at midnight of the 3d, and on the North Carolina coast on the morning of the 4th, having been fully justified.

No. III.—This area appeared in the Saint Lawrence Valley at midnight on the 7th, and moving in an easterly direction during the 8th and 9th, caused easterly winds and local rains in the Canadian maritime provinces and New England. At midnight of the 9th it had disappeared.

No. IV.—During the 11th the pressure rapidly increased in the extreme Northwest, and on the morning of the 12th an area of high barometer was central in the northern portion of the Missouri Valley, where the barometer was 0.3 inch above the normal. Following in rear of low area No. II. this area moved across the Lake region and up the Saint Lawrence Valley, and at the afternoon report of the 14th had disappeared. In advance of this area the temperature in the Lower Lake region, the Middle Atlantic States, and New England were extremely high. On the 11th and 12th a decided fall occurred in the Mississippi and Missouri Valleys, and on the latter date in the Lake region. An abnormal fall of 33° in eight hours was reported from Port Huron at midnight of the 12th. The maximum temperatures for the month in the Middle Atlantic States occurred on the 13th, at which time the high

area was in the Lake region, and the winds in the Middle Atlantic States were northwesterly. The temperature fell decidedly on the 14th.

No. V.—At the morning report of the 15th the pressures east of the Mississippi were below the normal. During the 15th the pressures recovered in the Lake region, New England, and the Saint Lawrence Valley. The barometer continued to rise rapidly in the Canadian maritime provinces during the 16th, and an area of high barometer remained nearly stationary in the Gulf of Saint Lawrence during the 16th, 17th, 18th, and 19th. On the latter date the pressures diminished somewhat, but recovered by the morning of the 20th, and continued high until midnight of the 21st, after which time the pressure decreased. This area, in connection with low areas Nos. III. and IV. caused strong northeasterly winds and heavy rains in New England and the Middle Atlantic States from midnight on the 15th until the 22d. Cautionary signals were ordered up at Eastport, Portland, Boston, and Wood's Holl at midnight of the 16th, and the signals ordered in advance of low area No. III. from Chincoteague to New Shoreham were kept displayed until the afternoon of the 17th, when lowered. The signals on the New England coast were lowered on the afternoon of the 19th. All signals were justified by the following maximum velocities: Eastport, N.E. 55 miles; Portland, N.E. 32; Boston, N.E. 36; Wood's Holl, N.E. 28; Thatcher's Island, N.E. 44; New Shoreham, N.E. 48; Sandy Hook, N.E. 26; and Chincoteague, N.E. 28.

No. VI.—The pressures remained above the normal east of the Mississippi after the passage of area No. V. During the 22d the barometer rose in Canada, and on the morning of the 23d a high area, of 0.3 inch above the normal, was central north of Montreal. This area moved slowly eastward; and at the afternoon report of the 26th was central east of the Canadian maritime provinces. On the 27th it had disappeared.

Areas of low barometer.—Five such areas are charted for the month of May. Nos. IV. and V. are specially interesting from the unusual paths pursued by them. None of the storms charted display particular energy.

No. IV.—This area was probably a secondary development of No. III. During the 16th and 17th the barometer continued low on the South Atlantic coast, and threatening weather with rain continued in New England and the Middle Atlantic States, in which districts the winds were under the influence of high area No. V., which was in the Gulf of Saint Lawrence. On the morning of the 18th a depression was central southeast of Cape Hatteras. At this time cloudy and rainy weather, accompanied by strong northeasterly winds, prevailed from Eastport, Me., to Cape Lookout. The cautionary signals which had been hoisted from Eastport to New Shoreham on the 16th were kept displayed. During the 18th the depression moved northward, and at the afternoon report was

east of Cape May. Thence it moved westward, and at midnight was central west of Barnegat, and on the morning of the 19th was west of Philadelphia. Thence it moved north to Ontario; was northwest of Rockliffe on the morning of the 20th, and afterward remaining nearly stationary, gradually filled up.

No. V.—On the morning of the 28th this area was central in the western portion of Minnesota. Light rains were reported from the Missouri Valley, and heavy rains, accompanying thunder-storms, from Texas. The depression moved slowly southward during the 28th, and on the morning of the 29th was southwest of Omaha, where it remained stationary until midnight. On the morning of the 30th it was southwest of Leavenworth; at the afternoon report it was central in Indian Territory. During the 31st it moved to Southern Texas, where it ceased to exist as an independent depression.

TEMPERATURE OF THE AIR.

The mean temperature of the air for May, 1881, is shown by the isothermal lines on the Chart. With the exception of the Rio Grande Valley, the Southeast Rocky Mountain slope, and the Florida peninsula, the temperature is everywhere above the normal, ranging from $+0.6°$ in New England to $+6.2°$ in the Upper Mississippi Valley. The greatest departures are confined to the northern portions of the country east of the 100th meridian. A normal condition is reported from the Florida peninsula, and only a change of $-0.5°$ from the Southeast Rocky Mountain slope.

Frosts were, with few exceptions, confined to that portion of the country north of parallel 40°. To the southward of that boundary they were reported as follows: Maryland, Fallston, 1st; Glyndon, 17th, 20th. Colorado, Pike's Peak, 13th, 21st, 22d, 25th. Nevada, Carson City, 7th, 17th, 18th, 19th, 23d, 24th, 25th. Arizona, Prescott, 11th. California, San Gorgonio, 1st, 2d, 11th, 24th to 26th; Campo, 26th, 29th, 30th. In the northern portion they were reported in the various districts as follows: New England, 1st, 3d to 5th, 14th; Middle States, 1st to 5th, 7th; Lower Lake region, 1st to 4th, 17th, 18th; Upper Lake region, 2d to 4th, 7th, 15th to 17th; Upper Mississippi Valley, 2d, 4th, 15th; Missouri Valley, 2d, 3d, 20th; Northern Rocky Mountain slope, 1st, 2d, 12th, 18th to 20th; Northern Plateau, 1st, 2d, 7th, 8th, 10th to 12th, 14th to 19th; North Pacific coast, 1st, 11th, 16th, 17th, 21st, 24th; Umatilla, 1st, injuring vegetation; Dayton, 22d, killing vegetables.

Ice formed during the month in few localities, and invariably in the region north of parallel 40°. Strafford, Vt., 1st, 3d, 4th, 5th; Mount Washington, 14th; Fall River, Mass., 1st; Rowe, Mass., 3d, 4th, 5th; Friendship and Flushing, N. Y., 1st; Milton, Pa., 4th; Chicago, 4th; Eagle Rock, Idaho, 7th, 18th, 19th.

PRECIPITATION.

The general distribution of rain-fall (including melted snow) for May, 1881, is shown on the Chart from the reports of over 500 stations. In general there is a marked deficiency for the month, which, however, is coupled with striking irregularities in the distribution, particularly in Texas and the Missouri Valley, where in several localities the heaviest precipitation ever recorded has fallen. This unusual record of rain-fall was probably due, in large measure, to the peculiar direction and sluggish movement of low area No. V. The largest deficiencies occurred in the South Atlantic, Eastern Gulf States, and in the North Pacific coast region, where, particularly in the two former districts, large excesses are common to the month of May. The largest excess was reported from New England, where the deviation from the normal for the month has not been exceeded in any previous year since the establishment of Signal Service stations. The deficiency in the Upper Lake region, although small, is not unusual, while over the Lower Lakes the deficiency, though larger, is considerably below the average. The deficiency in the Upper Mississippi Valley is very unusual and larger than ever before recorded.

In the Southern Pacific coast region the condition is normal, being the only district reporting the same. Throughout the San Joaquin and Sacramento Valleys the deficiency has been considerable, but few stations reporting any rain-fall at all, the largest being 0.79 inch at Red Bluff. Over the Rocky Mountain and Plateau districts there appears to be an excess at many stations, although the usual irregularity of distribution is observable. Elsewhere the changes are unimportant.

Cloudy days.—The number varies in New England from 5 to 17; Middle Atlantic States, 5 to 16; South Atlantic States, 3 to 10; Eastern Gulf States, 1 to 8; Western Gulf States, 2 to 14; Ohio Valley and Tennessee, 1 to 9; Lower Lake region, 4 to 11; Upper Lake region, 4 to 14; Upper Mississippi Valley, 4 to 14; Missouri Valley, 8 to 23; Red River of the North Valley, 8 to 14; Texas, 2 to 19; Rocky Mountains, 5 to 11; Middle Plateau, 4 to 6; Southern Plateau, 0 to 9; California, 0 to 12; North Pacific coast region, 6 to 11.

Rainy days.—The number of days on which rain has fallen varies as follows: New England, 10 to 18; Middle Atlantic States, 7 to 17; South Atlantic States, 5 to 14; Eastern Gulf States, 3 to 11; Western Gulf States, 8 to 18; Ohio Valley and Tennessee, 6 to 19; Lower Lake region, 10 to 17; Upper Lake region, 6 to 21; Upper Mississippi Valley, 10 to 15; Missouri Valley, 12 to 20; Red River of the North Valley, 11 to 15; Texas, 7 to 21; Rocky Mountains, 12 to 24; Middle Plateau, 2 to 6; Southern Plateau, 1 to 15; California, 0 to 6; North Pacific coast region, 2 to 13.

Rain from a cloudless sky.—Fort Myer, Va., 21st, 10.10 P.M., a

shower of rain, lasting five minutes, fell when the entire sky overhead seemed free from clouds, and stars could be seen shining brightly, although some light clouds were visible near the western horizon.

Snow fell, with few exceptions, over a narrow belt of country reaching from Northwestern Montana southeastward to Central Colorado, and was reported from various stations on the following dates: Fort Shaw, 22d, 23d; Helena, Deer Lodge, and Fort Benton, 22d; Fort Ellis, 13th; Deadwood, 11th; Fort Washakee, Wyo., 12th, 18th; Cheyenne and Denver, 17th; summit of Pike's Peak, 1st to 4th, 6th, 7th, 12th, 18th, 19th, 20th, 23d, 26th, 29th, 30th, 31st; Colorado Springs, 17th, 18th, 19th; Carson City, Nev., 22d on mountains west of station; Otego, Nev., no date; Summit and Truckee, Cal., no date, on summit of Mount Washington, 2d, 6th.

Snow on ground at end of month.—Pike's Peak, 16.50 inches.

Hail-storms were of frequent occurrence in various parts of the country, the most destructive being reported as follows: Newtown, Penn., 28th, between 5 and 6 P.M., very violent; thousands of panes of glass were broken, vegetable gardens and fields of grain entirely destroyed, fruit trees stripped of blossoms and leaves, and in several cases of bark. Path of storm very narrow, in some cases being so sharply defined as to follow the highway, committing damages on but one side. In some portions of the track hailstones as large as walnuts fell, covering the ground to a depth of 2 to 3 inches. Direction of storm-path, southwest to northeast, length about six miles. Terrific hail-storms visited this section about the middle of May, in 1860 and 1869. Belle County, Tex., 28th, P.M., very violent, destroying crops and damaging buildings; especial injury was inflicted upon corn, cotton, and wheat. New Hackensack, N.Y., 31st., during afternoon, terrific storm, extending from this point to Fishkill Plains. All grain along the storm's path entirely destroyed and corn and young fruit killed. Storm lasted about 45 minutes. Some hailstones were two inches in diameter, and on the following morning hail was found in some places a foot deep. Saint Clair, Mich., 14th, 3.30 P.M., rain fell in almost incredible quantities, and hailstones were as large as hickory nuts; a large quantity of window glass was broken and great damage done to fruit trees. Bellville, Mo., 14th, about 1 P.M., very violent; fruit trees and garden truck suffered severely; large quantities of window glass broken; much damage to farm crops. Brockway Centre, Mich., 14th, about 3 P.M., terrific storm of hail and wind, hailstones largest ever known to have fallen here; some measured 1½ inches in diameter. Hardly a house in the track of the storm but had all the glass in the north and west sides broken out. Several buildings were blown down and great damage done to grain crops and fruit trees. Length of storm path about six miles, direction from southwest to northeast. Bloomfield, N. J., 22d, hail fell in great quantities and of large size, doing terrible damage to greenhouses, tender plants and strawber-

ries. This storm was equally severe at other points in New Jersey, viz., Paterson, Orange, and Irvington. La Mesilla, 18th, half inch in diameter. Colorado Springs, 17th, 3.10 P.M., lasting 15 minutes; stones one inch in diameter. Spearville, Kans., 1st, stones size of walnuts; much property destroyed. Fort Davis, 2d, 4th, 26th, stones as large as quails' eggs. Highland Station, Tex., 8th, doing considerable damage to crops and window glass. Corsicana, 24th, hailstones as large as hickory nuts, great damage to growing crops. Macon, N.C., 18th, 10.07 to 11.45 A.M., completely destroying gardens and farm crops in vicinity. Nora Springs, Iowa, 30th, stones varying in size from peas to filberts.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, 71 to 89; Middle Atlantic States, 58 to 90; South Atlantic States, 59 to 81; Eastern Gulf States, 59 to 81; Western Gulf States, 66 to 77; Ohio Valley and Tennessee, 55 to 69; Lower Lake region, 62 to 75; Upper Lake region, 65 to 75; Upper Mississippi Valley, 57 to 69; Missouri Valley, 66 to 70; Red River of the North Valley, 67 to 69; Texas, 31 to 76; Middle Plateau, 26 to 34; Southern Plateau, 24 to 39; California, 39 to 75; Oregon, 44 to 57; Washington Territory, Olympia, 68. High stations report the following percentages, not corrected for altitude: Pike's Peak, 65.4; Santa Fé, 35.8; Cheyenne, 52.8; Denver, 52.2; Mount Washington, 82.1.

WINDS.

The prevailing winds during May, 1881, at Signal Service stations, are shown on the Chart by arrows which fly with the wind. Along the New England and South Atlantic coasts, and from the Ohio Valley southeastward to the ocean, they were from the northeast; along the Middle Atlantic coast, from southeast to southwest; throughout the Mississippi Valley and in Texas, southeast and south; in the Lake region, variable; in the Rocky Mountain region, southerly; over the Middle and Northern Plateaus and Northern Pacific coast region, north to west.

High winds.—Winds of 50 miles per hour and over were reported as follows: On summit of Pike's Peak, 10th, a violent hurricane prevailed, reaching a maximum velocity of 112 miles per hour at 12.15 A.M. of the 11th, when the anemometer cups were blown away. From this time until 2.30 A.M. the wind increased in violence, reaching an estimated velocity of 150 miles per hour. On summit of Mount Washington, 1st, 2d, 6th, 9th, 10th to 12th, 15th to 19th, 27th, 29th, 30th. Maximum velocity, 78 miles, N.W., 2d; Fort Keogh, 62, N.W., 21st; North Platte, 56, S.,

16th; Fort Elliott, 52, N.W., 7th, 8th; Fort Sill, 60, S.E., 8th; Decatur, 64, N.E., 25th; Indianola, 56, N., 29th; Eastport, 55, N.E., 17th.

Local storms.—Near Pensacola, Fla., 24th, very violent, buildings blown down, and many trees uprooted; rain-fall excessively heavy; Carpenter's Creek overflowed, and the ford on the Ferry Pass route was completely changed. McLenan County, Texas, 28th, P.M., in southern part, several farm-houses demolished and two persons killed; storm passed from S.W. to N.E.; in the northern part of the county, near Crawford, another violent wind storm passed from S.W. to N.E., unroofing and destroying buildings and seriously damaging crops. Dallas, Texas, 30th, very violent, unroofing buildings; rain fell in torrents. Taylor, Williamson County, Texas, 28th, P.M., very violent, lasting forty minutes; every building in the town more or less damaged; many were totally wrecked; in the county along the path of the storm fences were blown down and trees uprooted. Anna, Ill., 14th, heavy wind storm; portion of the Insane Hospital building blown down, and much other property damaged. Chester, Ill., 14th, terrific wind storm, much damage to property in lower part of town; roofs torn off and buildings demolished; considerable loss of property in surrounding country. Laurens County, Ga., 14th, during the evening tornado passed from N.W. to S.E. over the county, destroying everything in its path; the destruction of timber was almost unprecedented; where the storm-cloud passed over an oatfield, it literally tore up by the roots and carried away the grain over an area of 125 yards wide, leaving the standing grain on either side unruffled; the storm was accompanied at many places by heavy hail. North Platte, 9th, twenty miles east of station, demolishing houses, windmills, and the Union Pacific Railroad depot. Laredo, 8th, unroofing buildings, blowing down signs, trees, etc. Gainesville, Texas, 28th, 7 P.M., blowing down houses, trees, and fences. Montgomery, Ala., 31st, blowing down trees, signs, and fences. Columbus, Ohio, 14th, 5 to 5.30 P.M., air filled with débris, buildings unroofed, trees, fences, and signs demolished. Charlotte, N. C., 15th, 2.50 P.M., unroofing and blowing down large number of buildings, and committing other damage. Clay Centre, Kansas, 13th, six miles S.E. of station, tornado passed from S.W. to N.E., several buildings demolished. Yates Centre, Kan., 16th, small tornado passed over Owl Creek Township, nine miles N.E. of station, destroying two frame houses; direction of storm centre, S.W. to N.E. Westerville, Ohio, 14th, centre passed about one mile south of station in a northeasterly direction, blowing down trees, fences, and buildings. North Lewisburg, Ohio, 14th, very violent, blowing down trees, building, and fences; storm passed from S.W. to N.E. Milton, Pa., 10th, 6.30 P.M., unroofing buildings, uprooting trees, and blowing down fences.

Water-spouts.—Mobile, 31st, observed in Mobile Bay at 4.30 P.M.;

trunk was large and well-defined; moved from southwest to northeast; was visible for ten minutes. Clay Centre, Kan., 17th, 18th, 19th.

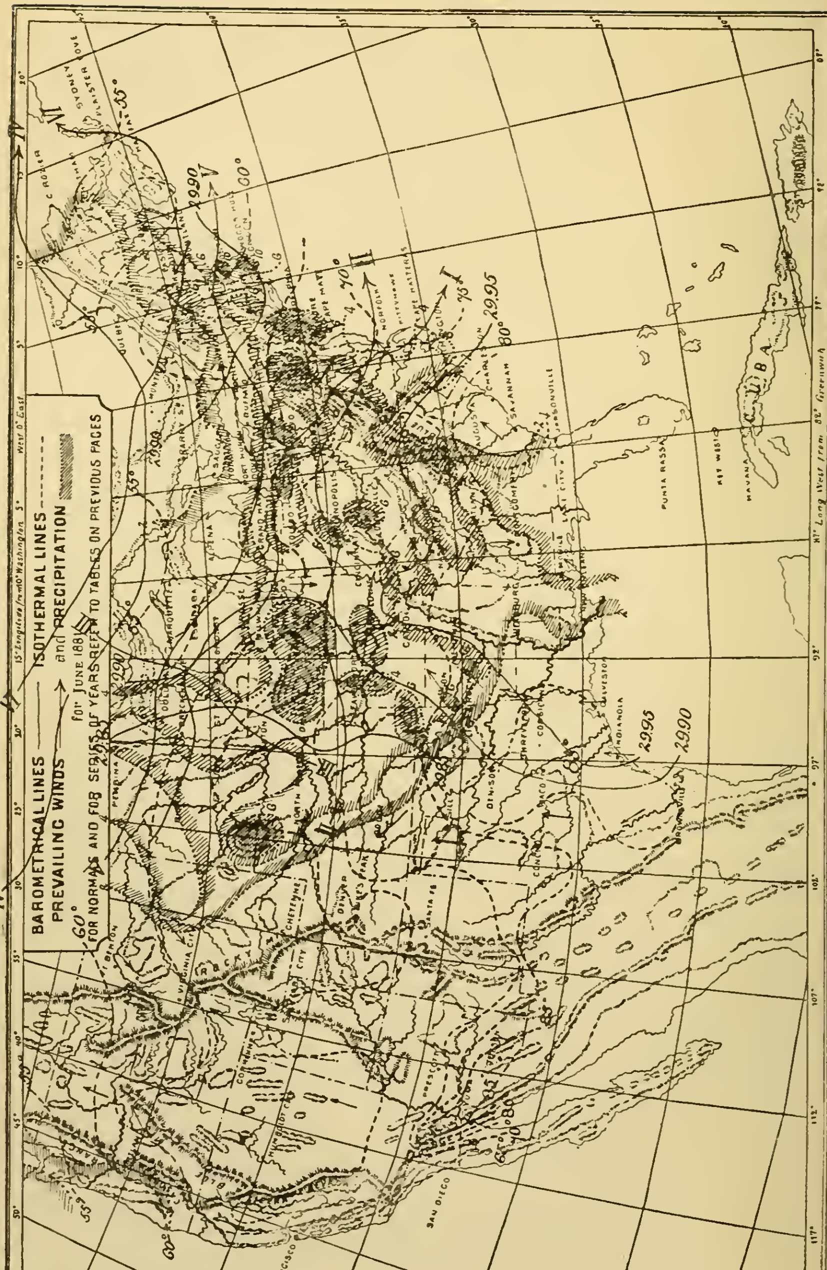
Sand-storms.—Fort Grant, 14th; Fort Verde, 10th, 22d; Tucson, 6th to 10th; Camp Thomas, 5th, 6th, 10th, 14th, 19th, 22d, 24th, 25th, 30th; Fort Yuma, Cal., 9th, 10th, 18th, 21st.

ATMOSPHERIC ELECTRICITY.

Thunder-storms.—In the various districts they were reported on the following dates: New England, 2d, 5th, 6th, 8th to 13th, 15th to 18th, 22d to 24th, 25th, 27th, 29th, 30th, 31st. Middle Atlantic States, 2d, 9th, 10th to 16th, 20th, 21st, 22d, 26th to 31st. South Atlantic States, 2d to 4th, 6th, 10th, 13th to 17th, 19th, 22d to 25th, 28th to 31st. Florida, 2d, 5th, 6th, 14th, 15th, 20th, 22d, 26th to 31st. Eastern Gulf States, 1st to 11th, 14th, 15th, 21st to 26th, 29th, 30th, 31st. Western Gulf States (including Texas), 1st to 12th, 16th to 31st. Ohio Valley and Tennessee, 1st to 10th, 12th to 14th, 22d to 24th, 26th to 31st. Lower Lake region, 5th, 8th to 14th, 28th, 31st. Upper Lake region, 7th to 9th, 11th to 14th, 26th, 27th, 29th, 31st. Upper Mississippi Valley, 1st, 2d, 4th, 7th to 14th, 16th, 19th, 21st to 31st. Lower Missouri Valley, 1st to 23d, 26th to 31st. Southern Slope, 1st to 3d, 12th to 15th, 17th, 18th, 22d, 24th, 25th. Middle Slope, 1st, 6th, 8th, 9th, 10th, 15th, 16th, 23d to 26th, 28th to 30th. Northern Slope, 3d, 4th, 6th, 8th, 9th, 10th, 15th, 22d, 24th to 31st. Southern Plateau, 14th, 15th. Middle Plateau, 9th, 10th, 15th. Northern Plateau, 3d, 4th, 8th, 12th, 20th, 22d, 27th, 30th. Southern Pacific coast region, 14th, 15th, 16th, 17th. Middle Pacific coast region, 1st, 15th, 21st to 24th. Northern Pacific coast region, 27th.

Atmospheric electricity interfering with telegraphic communication.—Fort Keogh, 31st, lightning very vivid and almost continuous, but no audible thunder; had to cut out instruments. Deadwood, 24th, 25th, 26th; Fort Griffin, 24th, 25th; Jacksonboro', 3d, 4th, 11th, 26th to 28th; Eagle Pass, 4th, 5th, 7th; Castroville, 5th to 7th, 17th, 18th, 28th, 29th; San Antonio, 28th, 29th; Fort McKavett, 3d, 17th, 18th; Brackettville, 3d, 4th, 5th, 7th, 18th; Fort Elliott, 12th; Mount Washington, 10th.

Ground currents.—Dayton, Wash., 30th; Deadwood, 23d.


BAROMETRICAL LINES
PREVAILING WINDS
ISOTHERMAL LINES
and PRECIPITATION
for June 1881
FOR NORMALS AND FOR SERIES OF YEARS REFER TO TABLES ON PREVIOUS PAGES
CUBA
SAN FRANCISCO
SAN DIEGO
SAVANNAH
GALVESTON
KEY WEST
HAVANA
PUNTA RASSA

12. MONTHLY WEATHER REVIEW, JUNE, 1881.

BAROMETRIC PRESSURE.

The distribution of mean atmospheric pressure over the United States and Canada for the month of June, 1881, is shown by isobaric lines upon the Chart. The region of the area of low, which is changed during the month of May from the Canadian maritime provinces to the Missouri Valley, still remains over the latter district, but with a more decided and extensive depression. The pressure over the former district has fallen very decidedly, forming an area of 29.85, which, with that over the Missouri Valley, makes two areas of low for the present month. For the same latitudes, the pressure is very evenly distributed over the country east of the 100th meridian, but it is generally low, the highest, 30.00, being reported from only two stations—Cedar Keys and Port Eads—and the lowest, 29.83, at Chatham, and 29.84 at Moorhead. There are two areas of comparatively high pressure, one covering the Gulf coast and the other the North Pacific coast. Compared with the preceding month, the pressure is everywhere lower, except over the Florida Peninsula, where there is a slight rise. The greatest change is shown over the Canadian maritime provinces, where a fall of 0.16 to 0.25 inch is reported.

Barometric ranges.—The range of pressure for the month has varied in the extremes from 0.18 inch at Campo, Cal., to 1.01 inches at Eastport. In general, the range varied from 0.4 to 0.6 inch. Along the southern boundary of the country, the range increases from California and Florida inward to the maximum at Brownsville, Tex., while over the northern boundary it diminishes from Washington Territory and Maine inward to the minimum in Montana.

Areas of high barometer.—Six such areas have been sufficiently important during the month of June, 1881, to merit description.

No. I.—This area appeared on the morning of the 1st over the Northern Slope and the eastern portion of the Middle Plateau region, where the pressure was from 0.06 to 0.1 inch above the normal. 2d, moved slowly eastward, covering the region from Western Texas northward to British America; barometer 0.09 to 0.2 inch above the normal. 3d, covered nearly the whole of Texas, and spread eastward over the Upper Mississippi Valley and western portion of the Upper Lakes; Leavenworth +0.19, Saint Paul +0.16, and Duluth +0.13 inch above the normal. On this and the preceding day the lowest temperatures of the month in Texas were recorded at most stations. During the 4th and 5th,

passed southeastward over Tennessee and the Ohio Valley to the South Atlantic coast. On these dates the lowest temperatures of the month in the Upper Mississippi and Ohio Valleys, Tennessee, the Eastern Gulf and South Atlantic States were reported from most stations.

No. II.—Appeared on the afternoon of the 5th over the Lake Superior region; Marquette barometer, 0.12 inch above the normal. By the afternoon of the 6th this area had spread southeastward to the Middle Atlantic coast and eastward to Maine; barometer 0.03 to 0.2 inch above the normal. 7th, pressure above the normal along the entire Atlantic coast from Key West to Sidney, Cape Breton Island. On this date occurred in New England the lowest temperatures of the month. 8th, disappeared over the ocean.

No. III.—As area No. II. left the Atlantic coast the pressure again rose decidedly over the Lake Superior region, and by the morning of the 9th the area of high covered the Missouri Valley, and extended thence northeastward over the Upper Lakes and Canada to the Gulf of Saint Lawrence; barometer from 0.03 to 0.18 inch above the normal. During the 9th the area spread southward to Tennessee and covered the whole of New England and the Canadian maritime provinces, where, in the latter district, the barometer was from 0.15 to 0.34 inch above the normal. 10th, pressure rose rapidly over New England and the maritime provinces, where the barometer was from 0.25 to 0.45 inch above the normal. 11th, pressure rapidly diminishing; area covered the country from the Ohio Valley and Tennessee eastward to the Atlantic. 12th, remained about stationary, pressure slowly rising along the immediate coast and in the maritime provinces. 13th, disappeared entirely during the night, except at Sidney, Cape Breton Island, which remained above the normal until the afternoon of the 14th.

No. IV.—On the morning of the 13th the pressure was slightly above the normal from Arizona and New Mexico northward to British America, and by midnight this area had extended eastward to the Mississippi, and covered every western district except the Middle Plateau and California, being from 0.01 to 0.11 inch above the normal. 14th, spread eastward to about the 80th meridian, highest pressure in the Missouri Valley; barometer slowly falling over the Rocky Mountain and Plateau regions. 15th, covered the entire country (except Florida) from Texas northeastward to Maine; barometer from 0.02 to 0.03 inch above the normal; highest over the Lake region. 16th, barometer above the normal over the entire country, except Florida, the maritime provinces, and the Upper Mississippi and Lower Missouri Valleys; highest pressure over the Lower Lakes. 17th, one portion of area disappeared off the South Atlantic coast and the remainder over the Mississippi Valley.

No. V.—Passed southeastward from the Saskatchewan Valley on the 19th; Fort Bufort barometer at midnight 0.27 inch above the normal. 20th, covered the region north of Iowa and Illinois and every district

westward to the Pacific, except the Middle Plateau; highest pressure in Dakota and Minnesota, where the barometer was from 0.13 to 0.3 inch above the normal. 21st, moved southeastward, the line of no change passing northeastward from Indian Territory to the eastern end of Lake Ontario; highest pressure still in the northwest. 22d, pressure above the normal over the entire northern half of the country, except New England; highest pressure over the Upper Lakes. 23d, pressure above the normal over the entire country north of the 35th parallel, except the Pacific coast; highest pressure over the Lake region. 24th, pressure everywhere above the normal, east of the 107th meridian, except along the Gulf coast; highest over the Lower Lakes. 25th, centre of highest pressure about stationary; area closing up from the south, the line of no change running eastward through Tennessee. 26th, pressure above the normal from the Gulf northeastward to the Saint Lawrence Valley; highest barometer over New England and eastward. 27th, by midnight area confined to the Canadian maritime provinces; barometer 0.1 to 0.19 inch above the normal. 28th, disappeared off the Nova Scotia coast during the afternoon.

No. VI.—On the morning of the 28th the influence of a high-pressure area was observed descending over Montana and Dakota from the Saskatchewan Valley and moving southeastward; by afternoon Fort Buford barometer 0.09 inch above the normal. 29th, A.M., barometer at at Bismarck 0.2 inch above the normal, the high area during the day extending southeastward into Iowa and Kansas. 30th, A.M., barometer at Duluth 0.18 inch above the normal; area extended southwestward into Colorado and northeastward over the Upper Lakes. By midnight the pressure was from 0.02 to 0.29 inch above the normal from Texas northeastward to the province of Ontario and northward to the Lake Superior region. Further description of this area will be found in the July, 1881, review.

Areas of low barometer.—Six such areas have been charted for the month of June, 1881. No unusual display of energy was noted in the progress of any of them.

TEMPERATURE OF THE AIR.

The mean temperature of the air for June, 1881, is shown by the isothermal lines on the Chart. Departures of such means from the average for many years. From Lake Superior southeastward to North Carolina, and thence northeastward to the Canadian maritime provinces, the temperature is from 2.7° to 4.4° below the normal; over the northern half of the Pacific coast, and in the Northern Plateau district, from 1.3° to 3.1° below the normal. Elsewhere in the various districts the temperature is from 0.4° to 5.1° above the normal, except in the Upper Mississippi Valley and South Pacific coast region, where no change is

recorded. Mount Washington is 5.3° below; Pike's Peak, 7.4° above, and Salt Lake City, 3.0° above.

High temperatures.—New Orleans, during the week ending June 18th, highest maximum temperatures in past 43 years; 12th, 91°; 13th, 92°; 14th, 95°; 15th, 94; 16th, 96°: 17th, 92°: 18th, 91°. Sunstrokes were numerous on the following dates: 14th to 17th, 21st, 23d, 25th to 27th. Laborers ceased work on 25th on account of extreme heat. Carthage, Mo., 10th, temperature 104° in the shade; all workmen on the Missouri Pacific Railroad compelled to quit labor. North Platte, 28th. temperature 94°; one case of sunstroke; first ever known here; Mobile 15th, sunstrokes reported; 24th, business suspended on account heat.

Frosts.—With the exception of Highlands, N. C., on the 5th, no station east of the 100th meridian and south of parallel 40° reported their occurrence. They were reported from New England and the northern portion of the Middle Atlantic States on the following dates: 2d, 5th to 7th, 15th, 16th, 21st to 24th; Lake region, 2d, 5th, 11th, 21st to 24th; Middle Rocky Mountain slope, 3d, 8th, 19th, 22d, 23d, 24th; Northern Plateau, 15th, 16th, 21st, 22d; Middle Plateau, 7th, 8th, 10th, 20th, 21st, 22d; North Pacific coast region, 8th; Southern California, 4th, 11th, 18th, 19th, 20th, 21st, 29th. They were reported as injurious to vegetation from various localities, as follows: Eagle Rock, 16th; Escanaba, 6th; Port Huron, 5th, 6th, 10th, 21st, 23d; Oswego and Mount Washington, 7th; Thornville, Mich., 6th, 21st, 22d, 24th; Friendship, N. Y., 22d; Dyberry, Pa., and Port Jervis, and Watertown, N. Y., 7th; Coalville, Utah, 22d.

Ice.—The only station reporting its formation during the month was Mount Washington, on the following dates: 3d, 4th, 5th, 6th.

PRECIPITATION.

The general distribution of rain-fall for June, 1881, is shown on the Chart, from the reports of over 500 stations. Upon examination of the chart and a comparison with the records of June for previous years, there is found a marked deficiency over the southern half of the country east of the 100th meridian. Other deficiencies are found in the Lower Missouri Valley, Minnesota, and Upper Lakes. The greatest deficiency occurred in the West Gulf States and Texas, where (particularly in the latter) a period of almost unprecedented drought occurred. There was a marked deficiency in the South Atlantic States—2.40 inches, but no reports of special suffering from drought are at hand. The excess of rain-fall was most marked from Canada southeastward to the Atlantic, over a portion of which region exceedingly heavy floods occurred. Slight excesses were reported in the Ohio, Upper Mississippi, and Upper Missouri Valleys, although there were many isolated cases of unusually

heavy rain-falls. Along the Pacific coast the range is from normal in the South Pacific region to +1.34 inches in the North Pacific region.

Rainy days.—The number varied in New England from 11 to 21; Middle Atlantic States, 11 to 18; South Atlantic States, 8 to 17; East Gulf States, 4 to 12; West Gulf States, 0 to 10; Ohio Valley and Tennessee, 14 to 21; Lower Lake region, 10 to 17; Upper Lake region, 12 to 20; Upper Mississippi Valley, 12 to 21; Missouri Valley, 14 to 17; extreme Northwest, 8 to 15; Northern Slope, 3 to 14; Middle Slope, 2 to 9; Southern Slope, 1 to 7; Rio Grande Valley, 1 to 2; Southern Plateau, 0 to 7; Middle Plateau, 1 to 5; Northern Plateau, 3 to 20; North Pacific coast region, 12 to 20; Middle and South Pacific coast regions, 0 to 4.

Cloudy days.—The number varied in New England from 4 to 14; Middle Atlantic States, 6 to 14; South Atlantic States, 0 to 17; East Gulf States, 1 to 8; West Gulf States, 0 to 3; Ohio Valley and Tennessee, 0 to 12; Lower Lake region, 8 to 12; Upper Lake region, 5 to 11; Upper Mississippi Valley, 5 to 16; Missouri Valley, 3 to 12; extreme Northwest, 6 to 13; Northern Slope, 3 to 10; Middle Slope, 0 to 3; Southern Slope, 0 to 2; Rio Grande Valley, 0 to 2; Southern Plateau, 0 to 7; Middle Plateau, 0 to 4; Northern Plateau, 4 to 14; North Pacific coast region, 14 to 20; Middle and South Pacific coast regions, 0 to 7.

Snow.—Carson City, Nev., 7th, fell on mountains west of station during night; Fort Bidwell, Cal., 7th; Bangor, Me., 16th; Mount Washington, 21st; Pike's Peak, 2d, 4th, 5th; Fort Benton, 9th, 11th, 22d.

Hail-storms were of frequent occurrence in various parts of the country, the most destructive being reported as follows: Franklin, N. H., 22d, about 4 P.M., many hail-stones were more than one inch in diameter; half the houses in the town had their windows shattered, and gardens everywhere were ruined; 28th, hail-stones fell more than half an inch in diameter; two-thirds of the buildings in the town had their windows shattered; crops in the surrounding country suffered severely. A violent wind accompanied the storm, which uprooted trees, demolished chimneys, and wrecked several buildings. Freight cars at the depot of the Northern Central Railroad were blown from the track. Wichita, Kans., 24th, most destructive ever known here. A section of country ten miles wide and twenty miles long, in the Arkansas River Valley, suffered very great damage. Thousands of acres of wheat, corn, and oats were cut down level with the ground; even the prairie grass was mown clean, while orchards and grape-vines were stripped of their fruit. Washington, D. C., 27th, most violent for several years; storm came up rapidly, and in the most threatening manner from the northwest, and continued about forty minutes. Hail-stones about the size of small hazel-nuts, hundreds of sparrows killed, considerable win-

dow-glass broken, and greenhouses and vegetable gardens injured. Storm was entirely confined within the city limits, and passed from N.W. to S.E. Patchogue, Long Island, 23d, very destructive; hail-stones of unusually large size, destroying crops and a large amount of window-glass. Andover, N. H., 28th, great loss to growing crops and window-glass. Mill Creek, Union County, Ill., 2d, ground covered to a depth of from 2 to 4 inches, and drifts 8 to 10 inches deep were reported from several localities. Wheat, corn, and fruit crops entirely destroyed over a section 2 miles wide by 10 miles long. Grant's Pass, Oreg., 9th, hail fell to the depth of several inches, and in many places drifted 3 to 5 feet deep; great destruction of property. Lewiston, Idaho, 3d, 3 P.M., heaviest hail-storm ever experienced in this section, some hail-stones measured 6 to 8 inches in circumference. The destruction of window-glass was very great, and in a number of places fields of grain were cut down as clean as if by machinery; direction of storm southwest to northeast; duration from 8 to 10 minutes. Asotin, Idaho, 3d, remarkably heavy; large number of sheep killed; chickens, goslings, curlews, doves, and other small birds were killed by the hundreds; storm lasted about 10 minutes. Anna, Ill., 2d, 4 miles west of station, most violent storm ever known; fruit, grain, and vegetable farms nearly devastated; hail a foot deep in some places on the following morning. Lamar, Mo., 9th, hail-stones size of goose eggs; windows broken in all parts of the town, and farm crops badly cut up. North Platte, Nebr., 9th, several miles west of station, many hail-stones reported to be 14½ inches in circumference, in several places telegraph wires were broken and roofs of houses punctured. 24th, all glass on the north and west sides of buildings destroyed; growing crops very badly damaged. Rome, Henry County, Iowa, 12th, violent hail and wind-storm; several buildings unroofed, and great destruction to window-glass and crops. Monteith, Guthrie County, Iowa, 12th, hail-stones tearing shutters to pieces and breaking window-glass; crops beaten into the ground, and much stock and poultry killed. At Adair, very heavy hail; several buildings unroofed. At Casey, crops destroyed and buildings badly damaged. At Mento, city hall unroofed, windows broken, farm crops ruined; almost impossible to estimate the damage. Avoca, Pottawattomie County, Iowa, 12th, 5,000 panes of glass broken; buildings otherwise damaged. In surrounding country calves, hogs, chickens, and ducks were killed by the enormous hail; cattle and horses were terribly bruised; hail-stones size of a man's fist. In Audubon and Cass Counties, 12th, hail-stones of remarkable size, and blown into drifts 2 and 3 feet deep; growing crops almost obliterated. Rockingham County, Virginia, 25th, near North Mountain, hail fell to a depth of 6 inches, the stones being of uncommon size, and remaining on the ground for 24 hours. Deadwood, Dak., 6th, during the afternoon hailstones, size of hen's eggs, fell for over two hours; one stone was reported to have

measured 21 inches in circumference. Cincinnati, Ohio, 13th, hail-stones from 2 to 6 inches in circumference, and some reported to have been 5 inches in diameter; 20 minutes after the storm stones were picked up as large as goose-eggs. Greenhouses and gardens damaged severely, and many thousand panes of glass broken; severest storm ever experienced. Abilene, Kans., 9th, continued for about 20 minutes, causing great damage to window-glass, trees, and garden crops; in country loss to crops very heavy. Beloit, Kans., 9th, very heavy, breaking window-glass and destroying crops. Solomon City, Kans., 9th, glass in the north windows of nearly all of the houses in the city were broken; hail-stones as large as walnuts, and covering the ground to a depth of several inches. Chester, Ill., 2d, hail-stones nearly the size of goose-eggs, doing great damage to gardens, trees, and windows, and severely injuring persons and stock. Storm continued for fifteen minutes. Clinton, Ill., 2d, great damage to fruit and growing crops. Storm continued for about ten minutes. Rockbridge, Ill., 2d, hail-stones 1½ inches in diameter; hundreds of acres of wheat completely torn to pieces, and not worth harvesting; fruit very badly damaged. Walnut Grove, Ill., 2d, over 500 acres of growing wheat and young corn terribly cut up; large amount of window-glass broken. White Hall, Ill., 2d, most violent storm ever experienced; great destruction of wheat, corn, potatoes, and fruit; a number of birds, chickens, and rabbits were found killed by the hail; direction of storm-path northwest to southeast; length about seven miles; width, one mile.

RELATIVE HUMIDITY.

The percentage of mean relative humidity for the month ranges as follows: New England, from 64 to 90. Middle Atlantic States, 60 to 82. South Atlantic States, 55 to 83. East Gulf States, 60 to 80. West Gulf States, 52 to 72. Ohio Valley and Tennessee, 62 to 77. Lower Lake region, 66 to 77. Upper Lake region, 69 to 76. Upper Mississippi Valley, 67 to 76. Missouri Valley, 66 to 68. Extreme Northwest, 65 to 74. Northern Slope, 57 to 66. Southern Slope, 29 to 57. Rio Grande Valley, 52 to 73. Southern Plateau, 18 to 25; Middle Plateau, 13 to 27. Northern Plateau, 37 to 48. North Pacific coast region, 66 to 73. California, 36 to 77. High stations report the following percentages not corrected for altitudes: Pike's Peak, 48; Santa Fé, 20; Cheyenne, 33; Denver, 31; Mount Washington, 78.

WINDS.

The prevailing winds during the month of June, 1881, at Signal Service stations are shown on the Chart by arrows which fly with the wind. Over the country east of the Mississippi and south of the Ohio,

southwest. Over the Lakes, northerly. Over the Middle Atlantic States and New England, variable. From Texas northward to Manitoba, southeast and south. Over the Plateau regions, south to west. Along the Pacific coast westerly.

High winds.—Winds of 50 miles per hour and over were reported as follows: On summit of Mount Washington, 3d, 5th, 6th, 10th, 14th to 20th, 27th, 29th; maximum velocity, 94 miles, N.W., 16th. On summit of Pike's Peak, 76 S.W., 15th; North Platte, 24th, 25th, 28th; maximum velocity, 60 W., 25th; Fort Keogh, 60 S.W., 5th; Portsmouth, 60 N.E., 22d; Sandusky, 57 N.W., 29th; Yankton, 56 W., 28th; Dodge City, 56 N.W., 25th; Thatcher's Island, 56 N.E., 10th; Fort Buford, 55 N.W., 10th; Cape May, 53 W., 8th; Stockton, 52 S.E., 28th; Fort Stevenson, 50 S.E., 15th; Delaware Breakwater, 50 N.W., 8th; Chincoteague, 50 S.W., 29th; Morgantown, 50 W., 29th.

Local storms.—Storms of this character have not been unusually frequent or severe during the present month, although the loss of life and property has been very great. The most destructive were confined to the region known as the Lower Missouri Valley, comprising the western portions of Missouri and Iowa and the eastern portion of Kansas and Nebraska. Several storms were reported by the newspapers and others as tornadoes, but, upon examination, they proved to be only very severe hail-storms or wind-storms of considerable force, the characteristics of a tornado proper not being manifested. The most violent of that class of storms, called tornadoes, occurred on the afternoon of the 12th, and during that portion of the day the peculiar atmospheric conditions which prevailed over the Lower Missouri Valley. The area of low barometer extended from the Upper Lake region southwestward to northern Texas, and thence northward to Manitoba. Along the southeastern edge of this area and northward to parallel 40° the winds from south to southwest, with temperatures ranging from 80° to 100°. Over Iowa, Nebraska, and extending thence westward into Colorado and Wyoming, a belt of north to northwest winds prevailed, with temperatures ranging from 63° to 78°. Confined to a region of country having a width of about 500 miles, a thermal difference of 37° was presented along the line of conflict between the opposing northerly and southerly winds. Bounded by the distinctive features of these atmospheric currents, it is found that Kansas, Missouri, Iowa, and Nebraska, but more particularly the two former, come within the region of violent wind-storms and tornadoes. Andrew County, Missouri, 12th, about 5 P.M., violent tornado formed eight miles northwest of Savannah, and passed in an easterly direction several miles north of the town. Its course continued a little north of east until it reached Flag Springs, when it bore still more to the north, passing over the village of King City, De Kalb County, after which its course could not be traced from the imperfect data at hand. During its incipient stages, the path of

destruction was about 160 yards wide, increasing thereafter to about one-quarter of a mile. The storm-cloud was funnel-shaped, with the smaller end towards the earth. At times it would careen from side to side, followed by an upward and downward motion of the body of the cloud, as if drawing itself into a sheath. Along the path of the storm everything was swept clean; the destruction of growing crops could not be estimated. About 80 buildings were demolished and 12 or 15 persons killed. One man was reported to have lost 80 head of cattle, another 250 sheep, and another 6 head of horses; other farmers lost heavily in stock, the losses of this nature being unprecedented. De Kalb County, Missouri, 12th, about 5 P.M., tornado formed several miles to southwest of Winslow, and moved thence northeastward, passing near that town. Continuing its northeasterly course, it reached the village of Berlin, Gentry County, thereafter disappearing to the northeastward near Grand River. Several persons were killed outright and many seriously injured. The destruction of houses, barnes, fences, and farming implements was very great. Width of storm-path about 200 yards. Nodaway County, Missouri, 12th, between 4 and 5 P.M., tornado formed in vicinity of City Bluffs, near the Nodaway River, and passed northeastward to the west of Hopkins. Several persons were killed and many buildings demolished. Indiana, Pa., 7th, very violent and destructive tornado; cloud funnel-shaped, small end toward the ground. Direction of movement southwest to northeast, passing over the most thickly settled portion of Washington, Wayne, and Cherryhill Townships. Fifteen buildings were destroyed, and a large amount of growing timber, fences, crops, etc. At some points, the storm was not more than 100 yards wide, and at times would appear to lift from the ground and again descend with redoubled fury. Length of storm-path over 15 miles. Loss of property estimated at $40,000. Osage County, Kansas, 12th, about 4 P.M., tornado formed east of Olivet, near the Marius des Cygnes River, and passed northeastward over the country lying to the south of Salt Creek, and traversing portions of Olivet, Melvern, and Agency Townships. At Quenemo, near the junction of Salt Creek and the river above named, many buildings were demolished, the débris being scattered for miles. Along the course of the storm, cattle were lifted into the air and dashed lifeless to the ground, articles of household goods were smashed into atoms, and bedding and clothing whipped into rags. In some cases, people were stripped of their clothing by the force of the wind, and small objects were carried several miles. Five persons were reported killed and over 20 wounded. Over 50 buildings were totally wrecked, and together with the loss to crops, fences, and orchards, the damage is estimated at $150,000. Cowley County, Kansas, 12th, about 4 P.M., tornado formed to the southwestward, near the Arkansas River, a few miles below Minnescah, and passed thence northeastward to the town of Floral, on Timber Creek, where it destroyed 28 houses, killed

3 persons, and wounded 22. The whole town was nearly wiped out of existence. Where the storm-cloud struck the creek, the water was sucked up and carried over the adjoining fields in the path of the storm. The leaves on the trees were withered, as by the heat of fire, and huge trees were pulled up by the roots or twisted off by the terrible force of the wind. The cloud was in hue a greenish-black, with streaks of fire apparently darting through it. Its form was funnel-shaped, with the smaller end toward the ground. Its movement was not altogether continuous and regular, but it would gyrate from side to side, and then dart forward with renewed energy. After leaving Floral, the storm's course was still northeastward, and great destruction to crops, fences, and buildings was caused in the neighboring county. Length of storm-path over 20 miles, the width varying from a few hundred feet to a quarter of a mile. In many instances, the line of destruction would be very closely defined, for on one side of a road the land might be swept clean, while no injury would be done on the other side. This storm is considered the most destructive that ever visited Southern Kansas. Belle Plaine, Sumner County, Kansas, 12th, about 4 P.M., tornado formed several miles to the southwest, near the Minnescah River. Course of storm-path northeastward, crossing the Arkansas River three miles south of Mulvane Junction. Cloud funnel-shaped, with the small end downward, drawing everything inward and upward. During the passage of the cloud, hail-stones over two inches in diameter fell in large quantities, and a hot southerly wind prevailed, which made it difficult to breathe.

Water spouts.—On Chesapeake Bay, off Hooper's Island, 9th, during the passage of a severe squall, a large spout suddenly descended, and, catching a small schooner near by, completely turned her over. Port Eads, La., 29th, two were observed at 1.20 P.M., over the Gulf to the southeast; they formed under a cumulo-stratus cloud in the shape of a cone; one disappeared before its completion; the other gradually elongated until it reached the water. The upper portion, or cone, was of the same color as the cloud, and the lower portion was of a light gray. It moved to the S.S.E., and at 1.28 P.M. broke, leaving a ragged edge, which rose to the cloud. Fort Stevenson, Dakota, 11th, observed about two miles from post before the approach of a terrific hail-storm.

Cloud burst.—Seven Star Springs, Barry County, Mo., 11th, broke in the hills above the town, the water rushing down, carrying away houses, household goods, and animals. Five persons drowned.

High tides.—Coney Island, 10th, unusually high, overflowed the meadows behind the hotels.

ATMOSPHERIC ELECTRICITY.

Thunder-storms.—In the various districts they were reported on the following dates: New England, 4th to 7th, 13th to 15th, 19th to 21st,

23d, 26th, 28th, and 29th. Middle Atlantic States, 1st to 10th, 13th, 14th, 16th to 21st, and 26th to 30th. Eastern Gulf States, 1st, 2d, 4th, 6th to 12th, and 14th to 30th. Western Gulf States, 1st, 2d, 4th, 6th to 10th, 13th, 14th, 16th, 17th, 19th to 27th, 29th, 30th. Ohio Valley and Tennessee, 1st to 9th, 13th to 21st, 23d, 25th to 30th. Lower Lake region, 1st, 2d, 6th to 8th, 12th, 13th, 15th to 17th, 20th, 25th, 27th, 28th. Upper Lake region, 1st to 3d, 5th to 8th, 11th to 13th, 16th, 18th to 20th. Extreme Northwest, 5th to 13th, 15th, 16th, 19th, 26th, 27th. Upper Mississippi Valley, 1st, 2d, 4th to 8th, 10th to 21st, 23d, 24th, 26th to 30th. Missouri Valley, 1st to 12th, 14th, 15th, 17th, 19th to 30th. Northern Slope, 1st to 15th, 18th to 25th, 28th. Middle Slope, 1st to 12th, 14th, 17th, 19th, 21st to 30th. Southern Slope, 1st, 2d, 5th to 12th, 25th to 27th, 29th. Rio Grande Valley, 6th, 8th, 20th, 26th, 29th. Southern Plateau, 3d, 5th, 14th to 16th, 18th, 24th. Middle Plateau, 4th, 10th, 13th. Northern Plateau, 1st to 3d, 7th to 10th, 13th, 14th, 18th to 20th, 23d, 28th. North Pacific coast region, 8th. California, 2d, 3d, 5th, 6th, 14th.

The following items of interest connected with the peculiar manifestations of electricity during the progress of thunder-storms were obtained from various sources: Williamsbridge, Westchester County, N.Y., 14th, at telegraph office, where 116 wires center, the electric current was so powerful that it drove every one out of the rooms. The switch-boards were covered with one sheet of fire; large balls of electricity leaped from the instruments and shot out from the pins and plugs at the ends of the wires. The manager of the office was knocked down as he approached the switch-board. In the vicinity of the town two boys were instantly killed as they took shelter from the storm under a large tree. Not a mark or bruise except a black spot on the left leg of one of them was found upon their bodies. The lightning followed down the trunk in a serpentine manner, boring a ragged hole in the ground near the roots. Wakefield, N. Y., 14th, house demolished, prostrating the inmates, and killing a horse standing in the street. One of the inmates was thrown violently to the floor, and had a hole about the size of a saucer burned in her dress. Brockport, Ind., 24th, two laborers having driven a reaping machine under a tree, were struck, one of them instantly killed, while the other had his pantaloon legs ripped open and his shoes torn off, but no further injury. Arcola, N. J., 14th, ice-houses fired and destroyed; one laborer was struck and thrown 40 feet. Elizabeth, N. J., 14th, while two persons were fishing in a sail boat upon Newark Bay one of them was killed instantly, leaving the other uninjured. His clothing was stripped from him and his left boot ripped open as if it had been cut with a knife. The lightning after leaving the body tore a large hole in the bottom of the boat. Anne Arundel County, Md., 10th, a barn containing 15 or 20 people was struck, killing four persons and severly injuring several others. Two of the victims

were fearfully burned, while the others showed only a purple scar where struck. Reistertown, Md., 10th, a young man killed while working in the field, his companion standing very close to him was only knocked down, but with no resulting injury. Henrietta, Tex., 9th, two ladies instantly killed while riding along in a carriage. Peoria, Ill., 11th, a farmer while crossing the iron bridge over Kickapoo River was instantly killed; his son close beside him was not injured. Hunnewell, Kan., 12th, a farmer instantly killed while unsaddling his horse in the barn. His clothes were completely torn from his body, his watch-chain melted, and his face and body badly mangled. The horse was killed, and one end of the barn torn out. Clinton Valley, Ohio, 20th, boy instantly killed while riding horseback. His body bore no marks, but the horse on which he rode was torn to pieces. Jamaica, N. Y., 23d, a young girl while seated under a tree was struck and knocked a distance of 10 feet, but not seriously injured; three other persons near by were fatally injured. Detroit, Mich., 16th, a house struck, blackening the walls and tearing off picture-mouldings. At the marine hospital a 40-foot flagstaff situated on the roof was shattered to within 20 feet of the base, where the electric current was conducted down the iron braces, making two small sharply cut holes in the corrugated iron roof. Ohio, 16th, the most destructive electric storm ever known was experienced throughout central and northern portions of the State. Dubuque, Iowa, 18th, a man while seeking shelter in an ice-house was struck, the lightning scorching one of his legs severely and tearing off his shoe and stocking. A brakeman leading two dogs within the yard of the Illinois Central Railroad Company had both of them killed while he escaped the slightest injury. At the Norwegian Plough Works the lightning made such a terrific display as to drive all the employés out of the buildings. At the Illinois Central freight office balls of fire were constantly shooting from the telephones. Warwatosa, Milwaukee County, Wis., 16th, during a light rain the lightning descended the chimney of a house, killing one of the occupants. The room in which the person was killed had the plastering torn from the walls; a heavy bedstead was jerked into the middle of the room, shivered into long pieces, and set on fire. A stove was smashed to atoms, and crocks, pans, and other wares were broken and twisted into all kinds of shapes. The other rooms of the house were not in the least affected, and six children sleeping in the main part were undisturbed.

Atmospheric electricity interfering with telegraphic communications.—Fort Sill, 6th, 7th, 9th; Jacksborough, 7th, 9th; Stockton, 1st, 5th, 6th, 8th, 26th, 27th; Decatur, 9th.

Auroras.—There were no unusually brilliant displays during the month, and no continuous observations on a single date embracing a considerable extent of territory.

CHAPTER XX.

THE SEASONS.

CERTAIN diseases, and the mortality arising from them, are so commonly identified with particular seasons of the year, as to have long since attracted the attention of observers to the influence of the seasons upon health in general, insomuch that the four seasons in temperate latitudes have come to be more or less identified with the preponderance of some diseases, and the absence of others to such a degree as to be a matter of common observation. Moreover, many people, and particularly chronic invalids, are so sensitive to the influence of the seasons, that in order to maintain a comfortable standard of health, they are constrained to avoid particular seasons by a change of climate. And thus it has come about that the identification of certain diseases with the season has not infrequently led the way to the more permanent conditions identified with climate.

In England, especially, where the mortality returns have attained a high degree of accuracy, more than thirty years ago Dr. Benjamin Ward Richardson made an analysis of the seasons in relation with 139,318 cases occurring during the years extending from 1838 to 1853, from small-pox, measles, scarlatina, whooping-cough, croup, diarrhœa, dysentery, cholera, influenza, ague, remittent fever, typhus, erysipelas, quinsy, bronchitis, jaundice, and carbuncle.

"Out of the 139,318 cases thus chronicled, as occurring from the above-named diseases, and estimating the gross mortality, according to the season, without reference to particular years, the percentage of mortality in the different quarters ran as follows:

In January, February, and March, . . .	25	per cent
April, May. and June, ...	25	"
July, August, and September, ...	14	"
October, November, and December, . . .	28	"

"Having learned thus much, I set about ascertaining, on the same large scale, whether the fatal diseases were in any way special to the seasons. The answer to the inquiry was to this effect:

"Whooping-cough, croup, small-pox, and bronchitis were most common in the first quarter.

	1st Quar.	2d Quar.	3d Quar.	4th Quar.
Small-pox, ...	27,352	24,551	22,824	25,272
Whooping-cough, ...	32,704	27,825	17,116	22,354
Croup, ...	27,523	25,100	19,919	27,456
Bronchitis, ...	36,793	20,301	10,327	32,570

"Pneumonia, I believe, might very properly have been added here.
'In the second quarter quinsy only stood ahead. Thus:

	1st Quar.	2d Quar.	3d Quar.	4th Quar.
Quinsy, ...	21,762	30,595	21,231	26,410

"In the third quarter, diarrhœa, dysentery, and jaundice took the lead.

	1st Quar.	2d Quar.	3d Quar.	4th Quar.
Diarrhœa, ...	10,196	10,717	58,519	20,567
Dysentery, ...	15,638	13,541	42,460	28,340
Jaundice, ...	24,877	24,030	26,967	24,109

"In this third quarter, Asiatic cholera, when epidemic, assumes a greater mortality and prevalence than at any other season.

"In the fourth quarter, influenza, ague, remittent fever, measles, erysipelas, and carbuncle took the lead.

	1st Quar.	2d Quar.	3d Quar.	4th Quar.
Influenza, ...	23,539	12, 171	4,502	59,785
Ague, ...	22,857	24,285	20,006	32,851
Remittent fever, ...	23,077	26,315	23,481	27,125
Typhus, ...	25,740	24,825	22,919	26,521
Scarlet fever, ...	20,809	18,978	26,234	33,976
Measles, ...	19,864	21,466	26,234	32,434
Erysipelas, ...	25,144	23,444	22,337	29,174
Carbuncle, ...	26,771	19,685	24,409	29,133

"In the first quarter the diseases of the respiratory system—croup, whooping-cough, and bronchitis—stand forth prominently, while in the fourth quarter a large family of diseases of the febrile or inflammatory order take the first position.

"It is not by mere accident that these divisions occur; they are the effects of fixed, though nearly unknown, physical or chemical laws.

"It is worthy of special remark that the fourth quarter of the year is that in which the number of diseases causing a prominent mortality is, as a general rule, greatest, and that next to it is the quarter commencing with the New Year. As the cold of winter more decidedly sets in, we begin to see developed, almost of necessity, an increase of death from pulmonary diseases, and of low fever amongst the poor, if provisions become high in price or deficient in quantity or quality."[1]

In the same work the author has also summarized:—

[1] "The Field of Disease," p. 530–523.

THE INFLUENCE OF WEATHER ON MORTALITY FROM DIFFERENT DISEASES AND AT DIFFERENT AGES IN LONDON AND NEW YORK.

BY ALEXANDER BUCHAN, F.R.S.E., AND ARTHUR MITCHELL, M.D., LL.D., F.R.S.E.

(From the Journals of the Scottish Meteorological Society, 1875-1878.)

PERIODS OF MORTALITY IN VARIOUS CONDITIONS OF DISEASE.

Irritation. Teething.

London.—Maximum.—January to middle of June and end of July; absolute, March, April.

Minimum.—Middle of June to end of December, with exception of last week in July; absolute, October, November.

Dropsy.

London.—Maximum.—November to April; absolute, February, March.

Minimum.—June to October; absolute, July, August.

Atrophy.

London.—Maximum.—July to September; absolute, August.

Minimum.—October to end of June; absolute, May, June.

Curve is allied to that for tabes, mesenteric and bowel diseases.

Mortification.

London.—Maximum.—Beginning of December to beginning of May; absolute, March, April.

Minimum.—June to beginning of December; absolute, August and September.

Senile Decay ; Old Age.

London.—Maximum.—Close of November to end of April; absolute, January.

Minimum.—May to close of November; absolute, July to October.

Very rapid rise in this curve in November.

PERIODS OF MORTALITY IN DISEASES RUNNING A DEFINITE COURSE IN BOTH SEXES AND ALL AGES.

LONDON AND NEW YORK.

Small-Pox.

London.—Maximum.—Last week of May.

Minimum.—Last week of September.

Above the average from Christmas to end of June.

New York.—Maximum.—May.
Minimum.—September.
Above the average from January to July.

Measles.

London.—Maximum.—Larger, November, December, January; smaller, May and June.
Minimum.—Larger, August, September, October; smaller, February, March.

New York.—Maximum.—Larger, July; smaller, February.
Minimum.—Larger, September; smaller, April

Scarlet Fever.

London.—Maximum.—September to end of year.
Minimum.—February to end of July
Highest death-rate through October and November.

New York.—Maximum.—December to June; absolute, April.
Minimum.—July to November; absolute, September.

Typhus.

London.—Maximum.—January to beginning of May.
Minimum.—Middle of May to end of September. Except hot season of July and beginning of August, typhus is below average from middle of May to end of September.

Typhoid Fever.

London.—Maximum.—October and November.
Minimum.—Middle of May to end of June.
Falls below average last week of February; begins to rise gradually in July.

New York.—Maximum.—August to November; absolute, September.
Minimum.—Nearly equal over other months of the year.

Remittent Fever.

London.—Maximum.—Larger, April to June; smaller, middle of December.
Minimum.—September.

Diarrhœa.

London.—Maximum.—Middle of July to beginning of August.
Minimum.—Absolute, March and April.
Maximum commences slowly in June; after August decreases (at a slower rate than it rose) until December.

New York.—Maximum.—July and August.
Minimum.—December, January, February, and March.
Death-rate begins to increase in April, two months earlier than in London.

Simple Cholera.

London.—Maximum.—July and August.
Minimum.—March and April.

Malignant Cholera.

London.—Maximum.—September.
Minimum.—April and May.
Mortality begins to rise in June, rises rapidly in July, maintains high and steady position in August, runs up to absolute maximum in September, and then rapidly falls.

Diphtheria.

London.—Maximum.—September to end of the year.
Minimum.—Middle of March to beginning of September.
Deaths remain above the average from September to the beginning of March.

New York.—Maximum.—December.
Minimum.—August.
Deaths above average from October to February; below it during the rest of the year.

Whooping-cough.

London.—Maximum.—February, March, and first half of April.
Minimum.—September and October.
Death-rate above average from middle of December to beginning of June.

New York.—Maximum.—Larger, September; smaller, February.
Minimum.—Larger, November; smaller, June.
The two maxima occur from August to September, and from February to April.
The two minima are from October to January, and from May to July.

Influenza.

London.—Maximum.—November, December and January, March and April.
Minimum.—Other months of the year.
Owing to the rarity of epidemics and the suddenness with which the disease appears and disappears, this cannot be accepted as the true curve of influenza.

Erysipelas.

London.—Maximum.—November.
Minimum.—Middle of June to middle of September.
Deaths from erysipelas are above the average from the middle of September to end of March; below for the rest of the year.

Puerperal Fever.

London.—Maximum.—November to March.
Minimum.—From middle of June to 4th week of September.
The curve of mortality tallies closely with that for erysipelas.

Hydrophobia.

London.—Maximum.—June, July, August, September, December· absolute, December.
Minimum.—February, March, April, May.
Calculation is based on fifty-six deaths in thirty years, twenty-three of which occurred in 1865–67.

Fevers in General.

London.—Maximum.—Beginning of September to end of January.
Minimum.—From April to August.
This curve has a well-marked character, though the departure from the average is never great.

PERIODS OF MORTALITY IN GENERAL DISEASES OF CONSTITUTIONAL TYPE, BOTH SEXES AND ALL AGES.

Rheumatism.

London.—Maximum.—End of November and beginning of December.
Minimum.—August and beginning of September.
The large November–December maximum is prolonged, but in a diminished form, to the spring months.

Gout.

London.—Maximum.—Middle of March to end of April.
Minimum.—Beginning of June to end of year; absolute, September.
A large increase takes place in last week in year. Another in middle of March ushering in annual maximum.

Cancer and Cancrum Oris.

London.—Maximum.—None.
Minimum.—None.

Scrofula.

London.—Maximum.—Larger, middle of April to first week of August; smaller, in October.
Minimum.—January, February, September, November, December.

Mesenteric Disease and Scrofula.

London.—Maximum.—Middle of July to middle of September.
Minimum.—End of December to beginning of February.
The mortality follows curve of temperature very closely.

New York.—Maximum.—July, August, and September.
Minimum.—December to early part of June; absolute, December and January.

Diabetes.

London.—Maximum.—None.
Minimum.—None.

Purpura and Scurvy.

London.—Maximum.—March to July.
Minimum.—December to beginning of January.

PERIODS OF MORTALITY OF LOCAL DISEASES IN BOTH SEXES AND ALL AGES.

DISEASES OF THE DIGESTIVE SYSTEM.

Thrush.

London.—Maximum.—Last week in July to third in August.
Minimum.—For the rest of the year; absolute in April and May.
The curve is identical in chief features with that of bowel complaints.

Cynanche-Quinsy; Tonsillitis.

London.—Maximum.—Middle of October to end of March; absolute, end of December and beginning of January.
Minimum.—August and beginning of October.
Maximum period is attended with a fall during February.

Gastritis.

London.—Maximum.—None.
Minimum.—None.

Enteritis.

London.—Maximum.—End of June to beginning of October; absolute, first week in August.
Minimum.—January, February, March, April, May, November, December.

Dysentery.

London.—Maximum.—June to November; absolute, second week in September.
Minimum.—April and May.
From November to June, death-rate under the average.

Intussusception.

London.—Maximum.—March, August, December, and first half of January.

Minimum.—End of May and beginning of June.

Below average from May to middle of November.

DISEASES OF THE HEART AND CIRCULATION.

Pericarditis.

London.—Maximum.—Middle of October to middle of May; absolute November.

Minimum.—Middle of June to middle of September.

Cu ve resembles that for rheumatism.

Heart Disease Generally.

London.—Maximum.—November to March; absolute, December and January.

Minimum.—Middle of April to middle of November; absolute, middle of August to middle of September.

New York.—Maximum.—November to May, with fall in February; absolute, December and January.

Minimum.—Middle of June to middle of October.

Curves for London and New York correspond closely.

RESPIRATORY ORGANS.

Croup.

London.—Maximum.—Middle of November to end of April; absolute, February and March.

Minimum.—Middle of May to end of September; absolute, middle of June to middle of August.

Absolute maximum is in early spring; absolute minimum in middle of summer.

New York.—Maximum.—From October to April; absolute, November and December.

Minimum.—May to September; absolute, July and August.

The curves for London and New York essentially agree.

Laryngitis.

London.—Maximum.—Beginning of December to end of May; absolute, last three weeks of March.

Minimum.—June to November; absolute, second week in September.

Sharp fall in January in maximum.

Bronchitis.

London.—Maximum.—November to March; absolute, second week in January.

Minimum.—April to October; absolute, August.

Above the average from November to April; below from May to October.

New York.—Maximum.—November to March; absolute, middle of March.

Minimum.—June to middle of November; absolute, first week in August.

The number of deaths from bronchitis in New York is only one-twentieth of the whole deaths, while in London it is one-eighth of the whole.

Asthma.

London.—Maximum.—From November to April; absolute, second week in January.

Minimum.—The beginning of May to end of October; absolute, August.

Pneumonia.

London.—Maximum.—November to April; absolute, December.

Minimum.—Beginning of May to end of October; absolute, August.

The curve generally the same as for bronchitis, but absolute maximum earlier.

New York.—Maximum.—Beginning of November to middle of May; absolute maximum, March.

Minimum.—Middle of May to beginning of November; absolute, July and August.

Phthisis.

London.—Maximum.—January to middle of June, and middle of November to middle of December; absolute, middle of March.

Minimum.—Middle of July to middle of November; absolute, fourth week of September.

The deaths from this disease are nearly one-eighth of all the deaths that occur.

New York.—Maximum.—Middle of December to middle of May; absolute, March.

Minimum.—Middle of May to middle of December; absolute, June.

The deaths from this disease in New York are greater than in London, viz., one-seventh of the whole.

Pleurisy.

London.—Maximum.—Middle of November to second week of June; absolute, December and January.

Minimum.—Beginning of July to end of October; absolute, July and August.

The curve is subject to numerous fluctuations, and resembles curve for rheumatism and pericarditis rather than bronchitis, pneumonia, or asthma.

Lung Disease Generally.

London.—Maximum.—From beginning of November to end of May; absolute, December and January.

Minimum.—June to November; absolute, July and August.

This group includes all diseases of the lungs not already specified.

DISEASES OF THE NERVOUS SYSTEM.

Cephalitis.

London.—Maximum.—From beginning of February to end of July; absolute, beginning of April.

Minimum.—From beginning of September to January; absolute, September, October and November.

Curve fluctuates considerably.

New York.—Maximum.—Beginning of February to end of August; absolute, July.

Minimum.—Beginning of September to beginning of February; absolute, November.

Hydrocephalus.

London.—Maximum.—From second week in February to beginning of August; absolute, March and April.

Minimum.—Second week in August to beginning of February; absolute, last week in October.

Mortality shows secondary increase in July as a constant feature.

New York.—Maximum.—January to beginning of August; absolute, April and July.

Minimum.—Second week in August to first in January; absolute, October, November.

Apoplexy.

London.—Maximum.—Middle of November to middle of April; absolute, December, January.

Minimum.—Middle of April to middle of November, with a rise in the last week in June; absolute, third week of July to beginning of September.

New York.—Maximum.—Beginning of December to end of May; absolute, March.
Minimum.—Beginning of June to end of November; absolute, July, August, September.

Paralysis.

London—Maximum.—Middle of November to end of April; absolute, end of January.
Minimum.—Beginning of May to middle of November; absolute, third week in September.
Differs from apoplexy in having maximum fatality in midwinter.

Epilepsy.

London.—Maximum.—Last week of December to third week of April; absolute, third week of March, first week of April.
Minimum.—Middle of July to first week of September; absolute, last week in August.

Convulsions.

London.—Maximum.—December to end of April; absolute, February and March.
Minimum.—Beginning of May to middle of November, with a small secondary maximum in July; absolute minimum in September, October.

New York.—Maximum.—June, July and August; absolute, July.
Minimum.—End of September to end of December; absolute, November, December.
Slight maximum in July in London is much exaggerated in New York curve.

Insanity.

London.—Maximum.—December, January, June, March, April; absolute, December and January.
Minimum.—Beginning of July to November; absolute, September, October.
The curve is very irregular.

All Nervous Diseases.

London.—Maximum.—Beginning of December to close of April; absolute, March, April.
Minimum.—Middle of May to close of November; absolute, September, October.

New York.—Maximum.—February to end of May slight, and close of June, July to middle of August; absolute, July.
Minimum.—Middle of August to middle of January; absolute, November.

Curve differs in New York from London owing to great maximum in July from sunstroke.

Brain Diseases.

London.—Maximum.—From beginning of December to end of April, with slight increases in July; absolute, March.

Minimum.—From end of July to end of November; absolute, September, October.

Curve almost identical with that for epilepsy. Includes all brain affections, except convulsions, epilepsy, paralysis, apoplexy, cephalitis, insanity.

DISEASES OF THE ABSORBENT AND GLANDULAR SYSTEM.

Hepatitis.

London.—Maximum.—Beginning of May to end of September; absolute, August.

Minimum.—October to end of April; absolute, December, January.

Jaundice.

London.—Maximum.—March slight, June, with a fall in July; through July, August, September; absolute, August.

Minimum.—November to June, with slight rise above the average in February, March, April; absolute, December, January, February.

Curve much resembles that of hepatitis.

Bright's Disease of Kidney.

London.—Maximum.—October to May; absolute, February, March, with a dip in December.

Minimum.—Middle of May to end of September; absolute, August, September.

Kidney Disease (General).

London.—Maximum.—End of November to end of April; absolute, December, January, and April.

Minimum.—Middle of May to September; absolute, June, August.

DISEASES OF THE MEMBRANOUS SYSTEM.

Skin Disease.

London.—Maximum.—October to middle of January; absolute, November.

Minimum.—End of May to beginning of September; absolute, June.

This curve comprehends all skin diseases, except phlegmon and ulcer.

DISEASES FROM NATURAL ACCIDENTS.

Childbirth. (Mother.)

London.—Maximum.—Second week of October to end of March; absolute, December, January.

Minimum.—May, June, July, August; absolute, June to August.

Premature Birth.

London.—Maximum.—January, February, May, July, August, December.

Minimum.—During remaining months.

Curve shows little variation from the average through the year.

Privation.

London.—Maximum.—December to middle of April.

Minimum.—Middle of April to end of November.

Curve allied to that of diseases of respiratory organs.

Want of Breast Milk.

London.—Maximum.—July, August, and September; absolute, July; August.

Minimum.—October to end of June; absolute, May.

This curve is allied to that from diseases of abdominal organs.

Alcohol Diseases and Delirium Tremens.

London.—Maximum.—Beginning of May to end of September; absolute, July.

Minimum.—Beginning of October to beginning of May, with rise to the average in October, and slightly above the average in first week of new year; absolute, January, February, March, December.

The curve for delirium tremens stands alone, resembles no other curve, and is steady.

Suicide.

London.—Maximum.—Latter part of March to latter part of August, absolute, end of June.

Minimum.—End of August to March; absolute, beginning of February.

New York.—Maximum.—Beginning of April to end of September; absolute, May.

Minimum.—Beginning of October to beginning of April; absolute, February.

Both curves have the maximum period in spring and early summer.

CHAPTER XXI.

THE RELATIONS OF CLIMATOLOGY TO LIFE INSURANCE.

ABOUT a dozen years ago, under the auspices of the "Chamber of Life Insurance," representing thirty American Life Offices, a "Collection of the Statistics of Mortality Experience, classifying, arranging, and tabulating them for practical use," was begun and after eight years completed in the form now before us.[1]

The diseases or causes of death are returned by twenty-seven of the thirty companies, including the general collection, and aggregate 37,624; of which 35,442 were of males, and 2,182 of females. There were also 8,919 deaths additional, not specifying diseases. 160 diseases are enumerated, and divided into seven classes:

Diseases and Deaths in Twenty-seven Life Insurance Companies from their organization to the year 1874.

DISEASES.	Males.	Females.	Totals.	% of Total.
All Causes,	35,442	2,182	37,664	100.00
Zymotic Diseases,	6,356	303	6,659	17.70
Constitutional Diseases,	8,175	548	8,723	23.19
Nervous Diseases,	5,106	193	5,299	14.08
Circulatory Diseases,	1,986	106	2,092	5.56
Respiratory Diseases,	4,771	291	5,062	13.45
Digestive Diseases,	3,344	273	3,617	9.61
Miscellaneous Diseases,	5,704	468	6,172	16.42

The principal or leading diseases in order are typhoid fever—which appears to have been quite uniformly distributed—5.99 per cent; other fevers, 4.35; consumption, 18.31; apoplexy, 4.70; paralysis and disease of brain, 4.34; heart disease, 3.61; pneumonia, 7.68; accidents and injuries, 7.21 per cent of all. Consumption, it is remarked, occurred at nearly uniform rates in all the companies, 18.31 per cent; and when increased, as it probably should be, by one-thirteenth of the deaths by

[1] "System and Tables of Life Insurances. A Treatise developed from the Experience and Records of Thirty American Life Offices, under the direction of a Committee of Actuaries." By Levi W. Meech, Actuary in Charge. 4to, pp. 553. Published by subscription. 1881.

pneumonia (chronic cases), and by deaths registered from abscess of lungs, hemorrhage of lungs, and disease of lungs, becomes 20.67 per cent, or more than one-fifth of the whole mortality.

Another table shows that the effect of medical selection is exhausted, and the average mortality of consumptive cases reached in the third year of duration of the insurance. The largest mortality by consumption occurs between the ages of 20 and 30 years. But after this period, the proportion of consumptive deaths of males bears a twofold aspect. That is, when compared with the number of living exposed, it slowly decreases to a minimum rate between 50 and 60 years, and then gradually rises again, with a heavy mortality all the while in every period of age.

Ratio of Consumptive Deaths to 10,000 *Living at each Age.*

Age, . . .	Under 20,	20–30,	30–40,	40–50,	50–60,	60–70,	70–80,	all ages
Ratio, . .	12.0	22.7	19.6.	17.4	15.8	17.6	19.1	18.6

But when compared with the total contemporary deaths, the proportion from consumption continually decreases, as the complementary proportion from other causes increases above the age of 30 years.

Passing now to the climatic distribution, we observe that north of latitude 36.30° the deaths from consumption are 18.7 per cent of the total deaths for male life, and 19.3 for females, while south of 36.30, the percentages are 12.3 and 9.0 respectively. The apparent deficiency from consumption in the latter proceeds only from comparison with a larger total, including an excess from malarial and other diseases.

Compared with the United States Census for 1870, the percentage of consumptive deaths, 18.3 in a total of 100 deaths insured, is less than the result of the Census, which is represented by 26.2 for males, and 29.7 for females. Thus the rejection of lives uninsurable from incipient consumption is manifest.

In proceeding towards the tropical regions, the ratio of deaths by consumption to those from other diseases gradually diminishes. The decrease, however, is not from absolute decrease of consumptive deaths, but entirely from increased mortality from other causes.

The practical question, What part of the United States is most favorable to consumptive invalids, can now be satisfactorily answered, so far as average yearly results are concerned, from the following interesting table:

Proportional Deaths and Diseases to 10,000 *Males living in each Group of States.*

Group of States.	*I.	II.	III.	IV.	V.	VI.	VII.	Mean Group.
All causes..........	105.3	97.7	107.1	104.5	130.5	170.5	112.2	
Summary.								
Zymotic	17.6	18.5	16.6	18.7	27.5	48.5	15.9	23.3
Constitutional...	26.4	21.4	27.9	23.0	27.3	26.3	22.1	24.9
Nervous.	15.4	11.5	15.4	14.4	20.1	22.3	18.4	16.8
Circulatory.. ...	6.6	4.4	7.3	4.6	6.7	6.8	9.2	6.5
Respiratory......	13.3	14.6	12.1	16.6	18.1	21.5	14.6	15.8
Digestive........	8.6	10.0	11.2	11.2	11.9	22.0	9.1	12.0
Miscellaneous....	17.4	17.3	16.6	16.0	18.9	23.2	22.9	18.9
Zymotic.								
Typhoid, typhus.	7.6	8.5	6.8	6.7	6.9	4.8	5.2	6.6
Malarial fever...	1.7	2.3	1.8	3.3	3.8	11.8	1.9	3.8
Erysipelas.......	1.0	1.3	1.0	1.3	1.3	1.5	2.2	1.4
Dysentery.......	1.7	1.4	.9	1.4	3.6	5.8	1.5	2.3
Diarrhœa........	.9	.7	1.0	.8	1.6	3.6	.2	1.3
Cholera	.9	.8	1.1	2.0	3.5	2.4	.9	1.7
Alcoholism......	.3	.3	.3	.4	.5	.3	.6	.4
Other zymotic. ..	3.6	3.2	3.7	2.8	6.3	18.2	3.4	5.9
Constitutional.								
Dropsy	1.8	1.6	2.6	1.9	2.2	2.2	1.9	2.0
Cancer	2.1	1.5	2.1	1.6	2.2	1.1	1.9	1.8
Consumption....	20.8	16.9	22.2	18.5	21.5	21.0	16.9	19.7
Other constitut'al	1.7	1.4	1.0	1.0	1.4	2.0	1.4	1.4
Nervous.								
Apoplexy...... ..	5.2	3.8	5.0	4.2	7.2	8.2	6.8	5.8
Congestion of brain.	1.5	1.5	2.1	2.5	2.9	4.9	1.7	2.4
Paralysis, softening of brain.	7.2	5.2	6.5	6.2	7.8	7.5	7.3	6.8
Epilepsy and convulsion.	.3	.3	.6	.4	.5	.7	1.5	.6
Other nervous...	1.2	.7	1.2	1.1	1.7	1.0	1.1	1.1
Circulatory.								
Diseases of heart.	6.1	4.1	7.1	4.4	6.3	6.6	7.4	6.0
Other circulatory	.5	.3	.2	.2	.4	.2	1.8	.5
Respiratory.								
Pneumonia......	7.3	8.5	6.6	9.8	10.8	12.6	9.0	9.2
Congestion of lungs.	1.8	1.7	1.2	1.7	2.2	2.2	.9	1.7
Bronchitis and pleurisy.	1.8	2.0	1.5	2.0	1.8	3.4	2.2	2.1
Abscess, hemorrhage of lungs.	1.9	2.0	2.0	2.4	2.4	1.9	1.8	2.1
Other respiratory	.4	.4	.8	.7	.9	1.4	.7	.8
Digestive.								
Diseases of stomach.	1.6	2.3	2.0	1.9	2.1	5.1	1.3	2.3
Diseases of bowels	1.9	2.2	2.5	2.5	2.5	5.8	1.6	2.7
Peritonitis.......	.7	.8	1.0	.8	.7	.5	.3	.7
Diseases of liver..	2.7	3.4	3.7	3.7	3.9	4.8	4.2	3.6

Groups.

*I.
New England.
New York.

II.
NORTHWEST.
Michigan.
Wisconsin.
Minnesota.
Nebraska.

III.
New Jersey.
Pennsylvania.

IV.
Ohio.
Indiana.
Illinois.
Iowa.
Kansas.

V.
Delaware.
Maryland.
Dist. Columbia
Virginia.
Kentucky.
Missouri.

VI.
SOUTH of 32.30°
North Carolina.
South Carolina.
Tennessee.
Georgia.
Florida.
Alabama.
Mississippi.
Arkansas.
Louisiana.
Texas.

VII.
PACIFIC, ETC.
Washington.
Oregon.
California.
Utah.
Dakota.
New Mexico.

Group of States.	I.	II.	III.	IV.	V.	VI.	VII.	Mean Group.	Groups.
Other digestive.	1.7	2.3	2.0	2.3	2.7	5.8	1.7	2.6	
Miscellaneous.									
Diabetes	.5	.5	.5	.4	.8	.3	.6	.5	
Disease of kidne's	3.5	1.4	3.1	1.9	2.1	2.4	2.6	2.4	
Other urinary....	.9	.8	1.1	.5	.9	1.2	.7	.9	
Child-birth, puerperal diseases.	......	.....	.....	.....	.....	.....	.....	......	
Disease of breast and uterus.	......	.. .	.....	....	.....	.....	.....	......	
Abscess, hemorrhage of old age	1.2	.8	1.1	1.1	1.3	1.0	.3	1.0	
Debility, exhaustion, etc.	1.0	1.0	2.4	.7	1.3	1.1	1.2	1.2	
Accidental injuries.	7.2	9.7	6.0	9.0	9.3	13.3	12.8	9.6	
Suicides..	1.3	2.1	1.3	1.3	1.8	1.4	3.3	1.8	
Unknown causes.	1.8	1.0	1.1	1.1	2.5	1.4	1.3	1.5	
Actual deaths......	15.273	2.716	3.976	6.239	3.306	2.153	863		

Briefly summarized, with special reference to consumption:

Ratio of Consumptive Deaths to 10,000 *Living.*

Groups of States, . .	III.	V.	VI.	I.	IV.	II.	VII.
Ratio, ...	22.2	21.5	21.0	20.8	18.5	16.9	16.9

Group III. comprises New Jersey and Pennsylvania; V., Delaware, Maryland, District of Columbia, Virginia, Kentucky, and Missouri; VI., States south of latitude 36° 30; I., New England and New York; IV., Ohio, Indiana, Illinois, Iowa, and Kansas; II., Michigan, Wisconsin, Minnesota, and Nebraska; VII., Washington, Oregon, California, Utah, Dakota, and New Mexico.

By an obvious generalization, the first four groups, comprising the *Atlantic and Gulf States*, from Maine to Florida and from Florida to the borders of Mexico, *have very nearly the same rate of consumptive deaths*, or 21 *annual deaths to* 10,000 *living*. The Western States show a decrease of the consumptive rate to 18½ in Group IV., while the Groups II. and VII., or Northwestern and Pacific States, agree in the more favorable rate of 17 consumptive deaths to 10,000 living. In establishing these important conclusions, the statistics entirely concur without discordance.

But the reader should not fail to observe that these conclusions are based upon the statistics of mortality of the *insured*—that they do not include deaths under fifteen years of age.

Grouped on the basis of the Census returns for 1880, when (as will be seen by reference to a previous chapter), the ratio of deaths from

consumption to all causes was 12.09, the ratios would stand under the same groups as follows:

Groups of States,	III.	V.	VI.	I.	IV.	II.	VII.
Ratios,	13.4	13.4	8.4	16.7	10.7	10.2	9.1

But this grouping, it hardly seems necessary to observe, after reference, as already made to table of the respective ratios of all the States, is manifestly unfair. For example, Missouri, with a ratio of 9.8, is placed in the same group with Delaware (16.1) and District of Columbia, 18.9. Again, New Mexico, with a ratio of 2.1; Utah, 3; and Dakota, 8, are grouped with Washington, Oregon, and California, with ratios respectively of 12.1, 13.2, and 15.5. A simpler grouping would be: I., of those States with ratios below 8 per cent; II., of those from 8 to 11 per cent; III., of those from 11 to 13 per cent; and IV., of those above 13 per cent. It would be as follows:

I. The District of Columbia, New England States, Delaware, California, New York, Tennessee, New Jersey, Ohio, Michigan, and Washington, 15.7 per cent.

II. West Virginia, Pennsylvania, Virginia, Indiana, Oregon, Maryland, Kentucky, and Wisconsin, 12.1 per cent.

III. Louisiana, Illinois, Iowa, North Carolina, South Carolina, Minnesota, Alabama, Dakota, Georgia, Nevada, Colorado, Florida, and Iowa, 9 per cent; and

IV. Kansas, Nebraska, Arizona, Idaho, Texas, Arkansas, Montana, Utah, Wyoming, and New Mexico, 5.4 per cent.

Moreover, the results, or rather the measure of the prevalence of consumption as summed up by the insurance companies—that the decrease from consumption in the warmer portion of the United States is not absolute, but entirely from increased mortality from other causes—is not in accord with the most recent census reports, either in respect to consumption or the general mortality.

THE RATIOS OF MORTALITY FROM ALL CAUSES, PER 1,000 OF POPULATION, IN THE SEVERAL STATES AND TERRITORIES OF THE UNITED STATES, ACCORDING TO THE CENSUS OF 1880, ARE AS FOLLOWS:

State.	Population.	Ratio.	State.	Population.	Ratio.
Alabama,	1,262,505	14.20	Kansas,	996,096	15.21
Arkansas,	802,525	18.45	Kentucky,	1,648,690	14.38
California,	864,694	13.32	Louisiana,	939,946	15.44
Colorado,	194,327	13.10	Maine,	648,936	14.87
Connecticut,	622,100	14.74	Maryland,	934,943	18.09
Delaware,	146,608	15.08	Massachusetts	1,783,085	18.59
Florida,	269,493	11.72	Michigan,	1,636,937	12.06
Georgia,	1,542,180	13.97	Minnesota,	780,773	11.57
Illinois,	3,077,871	14.62	Mississippi,	1,131,597	12.88
Indiana,	1,978,301	15.77	Missouri,	2,168,380	16.88
Iowa.	1,624,615	11.92	Nebraska,	452,402	13.10

State.	Population.	Ratio.	State.	Population.	Ratio.
Nevada,	62,266	11.69	West Virginia,	618,457	11.99
New Hamphire,	346,991	16.09	Wisconsin,	1,315,497	12.17
New Jersey,	1,131,116	16.33			
New York,	5,082,871	17.37	Arizona,	40,440	7.19
North Carolina,	1,399,750	15.36	Dakota,	135,177	9.64
Ohio,	3,198,062	13.32	District of Columbia,	177,624	23.60
Oregon,	174,768	10.66	Idaho,	32,610	9.90
Pennsylvania,	4,282,891	14.91	Montana,	39,159	8.58
Rhode Island,	276,531	17.00	New Mexico,	119,565	20.37
South Carolina,	995,577	15.79	Utah,	143,963	16.76
Tennessee,	1,542,359	16.80	Washington,	75,116	10.05
Texas,	1,591,749	15.53	Wyoming,	20,789	9.09
Vermont,	332,286	15.11			
Virginia,	1,512,565	16.13	United States (Total),	50,155,783	15.90

Divided into three groups, say of 12 and under, 12 to 15, and over 15 per 1,000 of population, the relative healthfulness of the different States and Territories of the Union, as measured by the ratio of deaths to population, stands in the following order:

I.	II.	III.
Arizona.	Michigan.	Delaware.
Montana.	Wisconsin.	Vermont.
Washington.	Mississippi.	Kansas.
Wyoming.	Nebraska.	North Carolina.
Dakota.	Colorado.	Louisiana.
Idaho.	Ohio.	Texas.
Oregon.	California.	Indiana.
Minnesota.	Georgia.	Rhode Island.
Nevada.	Alabama.	New Hampshire.
Florida.	Kentucky.	Virginia.
Iowa.	Illinois.	New Jersey.
West Virginia.	Connecticut.	Utah.
	Maine.	Tennessee.
	Pennsylvania.	Missouri.
		New York.
		Maryland.
		Arkansas.
		Massachusetts.
		New Mexico.
		District of Columbia.

In weighing the value of this summary, allowance should be made for density of population. With a few exceptions, for example, New Mexico and Utah in Group III., the highest ratios of mortality occur in those States where the population is most congregated in cities. And the close reader will not fail to observe that the preponderance of consumption holds the same relation.

CHAPTER XXII.

PRACTICAL CONCLUSIONS.

Some of the conclusions deducible from the evidence which has now been submitted in regard to the climatology of the United States are:

1. No country in the world possesses a greater variety of climate or climates with a higher degree of salubrity; but in this country, as elsewhere, the effects are measurably due to the various conditions which obtain among different populations and communities independent of the influences of climate *per se.*

General absence of cities and towns and their surroundings, recentness and sparseness of population, open-air pursuits and frugal diet, are important considerations promotive of the health of the people everywhere, above all to consumptives. And after all that has now been stated of the effects of the atmosphere in high altitudes or at the level of the sea, the influences of forests and ocean, of sea-coasts and interior places, humidity and dryness, cold and heat, the winds, electricity, and ozone, and no matter what of other conditions, the paramount considerations for the promotion of health are an *abundance of pure air and sunshine and outdoor exercise.* Without these no climate is promotive of health or propitious for the cure of disease; and with them it is safe to say the human powers of accommodation are such that it is difficult to distinguish the peculiarites of any climate by their joint results on the health and longevity of its subjects.

While evidence is still insufficient to show that any community of considerable magnitude, in any climate, is entirely free from pulmonary consumption, or that any climate confers immunity from that disease, it is doubtless to the greater freedom from impurities of every kind, constant freshness and concomitancy of sunshine more than to density, and notwithstanding an excess of moisture, that an ocean atmosphere is found to possess the highest degree of salubrity; and, moreover, not because it possesses a maximum amount of oxygen, contains small quantities of bromine and iodine, and is subject to more regular variations of barometrical measurement and greater equability of temperature than any other, though these may contribute somewhat to the good results.

2. Mountain air of an altitude of 2,500 feet and upwards, with rare exceptions, possesses the one chief attribute of salubrity common to sea-

air—freedom from organic impurities. Pasteur, Tyndall, and others have shown that the air of great altitudes is entirely free from organic impurities.

Miguel, as recently quoted by Weber,[1] gives the following interesting table of the number of bacteria found in ten cubic metres of air taken as nearly as possible at the same time in July, 1883:

1.	At an elevation of from 2,000 to 4,000 metres,	none.
2.	On the lake of Thun (560 metres), . .	8.0
3.	Near the Hôtel Bellevue, Thun (560 metres),	25.0
4.	In a room of the Hôtel Bellevue, .	600.0
5.	In the Park of Montsouris, near Paris, .	7,600.0
6.	In Paris itself (Rue de Rivoli) . .	55,000.0

This table is doubtless equally indicative of the difference in the amount of floating organic matter in the air at different altitudes, between town and country, and also between in-door and out-door air elsewhere, as in the places mentioned, and is particularly significant with relation to the commonly observed results on the health of persons subject to corresponding conditions. And, as remarked by Weber, it is likewise significant in the difference between the air on the lake of Thun (8.0) and on the shore, *i. e.*, the grounds of the Hôtel Bellevue (25.0). With this diminished amount of organic impurities coincident with increasing altitude, mountain air possess an increasing diathermancy, an excess of ozone, and a minimum of aqueous vapor. How far these generally accepted advantages of altitude compensate for the rarefaction of the atmosphere, the diminished amount of oxygen, the maximum diurnal variations of temperature, its lowest point, and the greatest and most irregular variations of barometrical pressure—qualities accepted as beneficial by some, and regarded as positively detrimental by many—is an important question for the therapeutist, rather than for the climatologist. That the results are frequently in the highest degree beneficial will scarcely be doubted by any one who carefully weighs the evidence submitted from which this conclusion is drawn.

It may here be remarked, however, that the basis of this conclusion is by no means confined to the region of the Western Highlands. The careful reader will not have failed to observe the disadvantage which obtains in some portions thereof—extreme aridity and inorganic dust—which should be avoided by invalids; nor should he lose sight of the eastern highlands of warmer latitudes—the Alleghany region of Georgia, the Carolinas, Tennessee, Virginia, West Virginia and Pennsylvania; and the White Mountains—which are devoid of such objectionable features.

3. The atmosphere of islands and sea coasts, places that are favorably

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[1] "Hygienic and Climatic Treatment of Chronic Pulmonary Phthisis," Lancet, September, 1885.

situated with regard to an abundance of sunshine and devoid of contaminating local conditions, is also proportionally free from floating matter; and it is generally sedative and tonic to consumptives, and fortifying to the human system in a state of health. These results are most manifest in islands situated far from the main land, and in peninsular places, of which Florida is a prominent example, and the more if in conjunction with pine forests, though the air in all such situations holds a proportionally large amount of moisture. But a sharp distinction is observable between the results of these conditions and those which obtain along the cold, damp, and misty sea coasts of New England, and some extensive marshy districts and river bottoms of several interior regions, which are of all others most predisposing to pulmonary diseases, both on account of their intrinsic qualities and the in-door confinements which the weather enforces.

4. The pine-forest regions, particularly of the Atlantic States, from Virginia southerly, at an altitude of from 500 to 1,500 feet above sea level, are notable for their salubrity at all seasons, and especially for the small ratio of deaths from pulmonary diseases. Moreover, similar results obtain on the Pacific coast: pulmonary diseases are more prevalent in the northern and colder regions than in the southern and warmer.

5. Temperature, *per se,* as will be found on reference to tables for all latitudes and altitudes, appears to have but little influence. But whenever the extremes are such as to deprive persons of the benefit of open-air exercise they are proportionally detrimental. By a careful study of the isothermal lines on the Charts, however, and comparing their course with the results of the statistical tables for the several States, as the annual mean temperature rises there is a marked decrease in the consumption death-rate. This is most marked in Florida. Southern Louisiana is exceptional by reason of its greater density of population—comprehending New Orleans in relation with the moisture from a filthy soil.

6. The relative humidity of the atmosphere is, perhaps, of all conditions, the one to which most importance is attached, and with special reference to pulmonary diseases. But careful study of the hygrometric tables and charts, in relation with altitudes, will show that it, like temperature, is greatly influenced by local conditions. Indeed it is difficult to trace that moisture has any influence *per se.* Moreover, it will be found that the amount of rain-fall is no criterion by which to measure the hygrometric state of the atmosphere; and with reference to salubrity, the *disposal* of the rain-fall is much more important. A soil which will not readily dispose of it, or local conditions which contaminate it, are always important. But with special reference to the degree of atmospheric moisture deemed to be most desirable for consumptives, Jaccoud[1] says the desir-

[1] "Curability and Treatment of Pulmonary Phthisis."

able limits are to be found between 70 and 80 hygrometric degrees. This statement, in conjunction with the hygrometrical measurements and the ratios of deaths from pulmonary diseases in different localities, will be found perfectly consistent with the results deducible from the statistical evidence of this volume.

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